Emotions, Behaviour and Belief Regulation in An Intelligent Guide with Attitude

by

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I hereby declare that the work presented in this thesis was carried out by myself at Heriot-Watt University, Edinburgh, except where due acknowledgement is made, and has not been submitted for any other degree.

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Abstract

This thesis describes a biologically-inspired body-mind architecture for emotions, behaviour and belief regulation. The interest lies in modelling the conditions to the emergence of emotions instead of programming emotions. Emotions are not defined explicitly, but evolve from modulation of perception, motivation, action-selection, planning and memory access. The resulting agent acts as a context-aware mobile tour guide, guiding visitors touring an outdoor attraction, as well as presenting stories about the site and events. In addition to giving the illusion of life, the guide emulates a real guide's behaviour by presenting stories based on factors such as the user's interests, its own interests and its current memory activation. It possesses emotional memories that hold information about its past and its ideological perspectives, providing it with a personality. This allows the guide to present its autobiography on top of facts. The related literature and the steps involved for the realisation of the proposed guide are presented. By having the body-mind architecture, the guide shows plausible, flexible and adaptive emotions, behaviour and belief. The system has been successfully evaluated and the result shows that the body-mind architecture is able to create a guide that provides a more interesting and enhanced tour experience.

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2. Mei Yii Lim and Ruth Aylett, Intelligent Mobile Tour Guide, *Symposium on Narrative AI and Intelligent Serious Games for Education, AISB'07*, Newcastle, April 2-5, 2007

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Chapter 1

Introduction

> Enthusiasm is excitement with inspiration, motivation, and a pinch of creativity.
> - *Bo Bennett.*

> History in some ways resembles the relativity principle in science. What is observed depends on the observer.
> - *Edward Teller, Standford, California, December, 1982 in Introduction, Now it can be told: The story of Manhattan Project*

Imagine arriving at a new historical site. You are impressed by what you see but curiosity rises. Questions start popping up in your mind. Does this building have some hidden secret? Who lived in this cottage and what was their lifestyle like? How did the fountain come about? Why does it have a figure of an eagle on its tip? Where does the path behind that garden lead to? And many more. Of course, if there is someone around, you can ask them. If there is not, maybe you could have a virtual guide that accompanies you around all these interesting artifacts for as long as you wish, telling you stories about them based on your interests.

1.1 Motivation and Goal

Context, description of the surrounding facts that adds meaning, is currently receiving growing attention in the mobile computing domain [Schmidt et al., 1999]. Context-awareness in mobile computing concerns the awareness of the physical and social environment surrounding the user to better support them, which may include location, orientation, time, the user's condition, physical conditions of the environment or nearby people and objects. In the scope of this thesis, context simply refers to the location, orientation and the opinion of the user.

A growing area of context-aware applications is tourist guidance systems, however, currently lacking 'intelligence' and 'life'. In more intelligent computing environments, more human like communication methods will play the key role [Kruppa, 2004]. In interaction with current virtual guides, users tend to lose interest rapidly due to lack of 'life' and unmet expectations of the character's intelligence. This problem should be solved in order to prolong and produce a more engaging and natural interaction between guide and user. The focus of human reaction to believable agents is on the social and emotional dimension of computer technology, which challenges the traditional conceptions of intelligence and design of intelligent systems where AI is modelled as problem solving, the internal manipulation of symbols representing items in the real world.

Damasio [1994] hypothesizes that emotion plays a biasing role in decision making. His patients with frontal-lobe disorders suffer from an impaired ability to make decisions. The frontal-lobe disorder in these patients interferes with their ability to combine emotional limbic responses with their otherwise cortical decision making. Hence, Damasio provides neurological support for the idea that there is no 'pure reason' in the healthy human brain but emotions are vital for healthy rational human thinking and behaviour. This implies that both the cognitive and physiological systems are essential parts of future intelligent computers. He also points out that emotions play an important role in social interation and social thinking.

Supporting the argument, animators felt that the greatest significant quality in characters was appropriately timed and clearly expressed emotions [Bates, 1994]. The famous Bugs Bunny animator, Chuck Jones said that it is the oddity, the quirk, that gives personality to a character and it is personality that gives life. An emotionless character is lifeless, a machine. Dautenhahn [1998b] argues that the better computational agents can meet our human cognitive and social needs, the more familiar and natural they are, and the more effectively they can be used as tools.

Further, we argue that the lack of intelligence and life reduces the user's enjoyment during an outdoor tour visit. Additionally, one can argue that it reduces motivation to learn and explore an attraction, hence, diminishing the absorption of information. A tour guide should provide the appropriate amount of intelligence and impetus to foster learning and self-development, so as to create a meaningful and engaging experience. Hence, the successful linking of body-mind, the link between the lower-physiological and higher-cognitive systems is essential to allow transparent flow of information from one level to another, and allow appropriate monitoring of the guide's behaviour. The guide has to possess variable emotions, act appropriately and effectively, interesting and distinctively individual.

This thesis discusses the creation of an 'intelligent guide with attitude' - a guide with emotions and personality, hereafter termed as the Affective Guide, to provide guidance, interesting and engaging interaction on a mobile platform. It addresses the frustration that usually occurs in the interaction with an emotionless computerised system that does not react intelligently to a user's feelings. The guide incorporates its belief, interests, user's interests and its current memory activation to narrate stories. Decisions on story generation and update of belief about user's interests are affected by its internal processing that is controlled by an emotional model, which receives input from the user. The emotional architecture of the guide is biologically inspired where the interest lies in modelling the conditions to the emergence of emotions to avoid rigidness in behaviour and provide more colour to the resulting emotions. The emergent approach aims to produce a natural agent that adapts to the environment flexibly.

According to Tozzi [2000], one of the most striking features of historical investigations is the coexistence of multiple interpretations of the same event, depending on the storyteller's perspective. In accordance with this finding, the presentation of information from different viewpoints, depending on the guide's role and interests, is emphasized. By seeing things from a particular perspective coupled with his own knowledge and understanding, a user will be able to analyse, enquire, reflect, evaluate and use the source of information critically to reach a conclusion of why different historical interpretations exist, hence producing a deeper learning experience. This research moves away from the concept of a guide that recites facts about places or events towards a guide that utilises improvisational story-telling techniques [Ibanez, 2004]. Contrasting views and personality are achieved with an inclusion of emotional memories containing the guide's ideology and its past experiences.

The Affective Guide is implemented on a PDA, taking advantage of the expanding technologies such as Wi-Fi wireless hotspots and bluetooth access points, freeing the user from carrying the traditional heavy and bulky devices. Multiple modalities are used to complement each other and focus the user's attention on the information presentation. Touristic information is location-dependent by nature, thus, the system links electronic data to actual physical locations, thereby augmenting the real world with an additional layer of virtual information.

The main aim of this work is to implement context-aware, affective and intelligent guides with attitude, advancing the development of existing context-aware tourist guidance systems [Abowd et al., 1997, Sumi et al., 1998, O'Grady et al., 1999, Petrelli et al., 1999b, Höllerer et al., 1999a, Malaka and Zipf, 2000, Bertolleti et al., 2001, Almeida and Yokoi, 2003, Stock and Zancarano, 2002] described in Chapter 2 by making interaction more natural and interesting, thus, improving tour experiences. This thesis presents the most relevant knowledge from the fields of Mobile Computing, Artificial Intelligence, Psychology, Brain Research, Personality and Narrative, sufficient for the realisation of the Affective Guide.

1.2 Summary of Main Contributions

The contributions resulting from the work presented in this thesis are listed below, divided into two categories:

1.2.1 Novel Contributions

- A novel body-mind architecture for emotions, belief and behaviour regulation in a virtual agent. This architecture creates a guide that can provide a more interesting and engaging interaction. The design involved integration of a biologically-inspired model of emotions, whereby emotions and personality emerge from modulation of information processing; and an improvisational story-telling model that takes into consideration the guide's perspective and the user's interests. An emotional memory that reflects the guide's personality is also included. The resulting guide possesses a flexible and adaptive behaviour according to the condition of the interaction environment.

- A structure for coding the emotional memory for the guide including the 'arousal' and 'valence' tags. This memory stores the guide's past experiences and ideological perspectives, and when retrieved, allows the guide to re-experience the event and express itself analogous to a real guide. The emotional memory forms part of the guide's long term memory that holds both locational facts and its previous experiences.

- A reusable flexible approach for mapping three facial aspects: the eyes, the mouth and the eyebrows to the emotional dimensions space of arousal and valence. A combination of the facial expressions resulting from this mapping and the colour changes along the emotional dimensions provide means for expressing the internal states of the guide.

- A proposal of the relationship between ideology and emotions. The impact of emotions on ideology and vice versa is thoroughly explored. The relevance and reflection of this relationship in the guide is discussed.

1.2.2 Other Non-Novel Achievements

- A reusable algorithm for the construction of all possible source-destination attraction pairs and the distance between them. The algorithm requires information of all available nodes and sidenodes to perform the necessary generation.

- A navigation planner that guides the user from one location to another during the tour. The planner performs continuous planning where only the next stop is generated at each processing cycle and the direction of travel is continuously updated as the user walks around. The planner uses the information generated by the reusable source-destination algorithm.

- Implementation of the Affective Guide system which involved integration of various mobile components including a PDA, a text-to-speech system, and a global positioning system. Furthermore, realisation of the processing is performed by combining the novel architecture, navigation planner and the facial mapping model. The user inputs using the graphical user interface, and receives visual, text and audio output.

- Findings from the survey on tour guide experiences.

- Results obtained from the evaluation with real users on the guide's story-telling capabilities, the guide's facial expressiveness, the guide's character, the participant's tour experience, user interface and the participant's recall level.

1.3 Process and Methodology

The goal of this research is to create a more interesting and engaging mobile tour guide agent. To achieve this, mobile context-aware applications are studied. It was found that current tour-guide applications are quite rigid, provide repetitive stories and lack intelligence. To achieve flexibility and increase the guide's intelligence, an improvisational story-telling architecture was selected. This architecture was designed for a virtual guide in a virtual environment [Ibanez et al., 2003], it does not incorporate user interaction. As a consequence, it does not take into account the user's interests and responses, two factors which from a brief survey on tour guide experiences, were found to be important for story generation. This called for a modification of the existing architecture.

Besides intelligence, emotions are necessary for an effective computer system. Picard [1997] argues that "a machine, even limited to text communication, will be a more effective communicator if given the ability to perceive and express emotions". From this argument, inclusion of emotions for the tour-guide becomes more vital especially when interaction with a human user is the goal. Some of the existing mobile tour-guide applications do employ life-like animated characters [Sumi et al., 1998, Not et al., 1998, Doyle and Isbister, 1999, Bertolleti et al., 2001, Stock and Zancarano, 2002, Almeida and Yokoi, 2003, Braun, 2003] as described in Chapter 2. However, these characters are usually pre-programmed to respond to the users using a few pre-defined actions and expressions over and over again, missing 'life' and again, flexibility.

A more human-like interaction is required, and this is accomplished by designing a body-mind architecture for the guide. Therefore, a flexible emotional model was sought. A functional model of motivation, cognition and emotion was selected. This model has been applied to autonoumous agents [Bartl and Dörner, 1998, Hoyer, 2004], emotional robots [Dörner and Hille, 1995] and in simulation programs [Dörner, 2003, Schaub, 2004] described in Chapter 3. This architecture produces emergent emotions by focusing on cognitive modulation of perception, action-selection, planning and memory access to emulate human action and belief regulation.

Having the requirements, an initial design draft was drawn using the story-telling and emotional architecture as bases. The emotion model forms an integral part of the guide's body-mind model, affecting its emotional states, the way it processes information and the way it generates stories. An iterative process took place for the architectural design. The research continued with exploration of emotional memory, personality and beliefs. The criteria for refinement of the guide's internal architecture were based on the characteristics of real guides. The initial design was continuously elaborated as more knowledge was acquired. From time to time, more functionalities and components from the different fields were added to the initial design until it evolved into the final version. Additionally, means for reflection of the guide's internal state were explored.

In parallel, methods for mobile components integration were explored and user interface design for the interaction on the PDA was performed. In terms of development, the rapid prototyping paradigm offered the best approach as accurate requirements were not defined at the early stage. An open-ended approach, called evolutionary prototyping [Pressman and Ince, 2000] was adopted. The development started with the integration of all mobile components and the construction of the graphical user interface. When an acceptable design of the guide's body-mind architecture had been achieved, the development of the guide's internal structure began. The prototype was formulated to be as extensive as possible so that only minor requirements are necessary in the later phase to have a finished system. The prototype became a mechanism for identifying problems and unforeseen requirements. The progress and outcome of the development process affect the architectural design and the refinement on the architectural design necessitates changes to the system under development. This process continued until all the necessary features were implemented and a functional system was achieved.

It has to be stressed that we are not trying to replicate the real human guide, but to create a virtual guide that has some of the behaviour common to its real-life counterpart. The aim is to produce a virtual guide that is more intelligent and provides the 'illusion of life', thus improving tour experiences.

1.4 Overview of the Thesis

This thesis is divided into eight chapters and eight appendices. Chapter 1 gives an overview of the work performed. It answers the why, what and how questions.

Chapter 2 explores work on tour guide systems including mobile and virtual tour guide systems. It describes the main features significant to such systems and presents some future considerations of the existing systems. It also presents a comparison and inspiration of the existing work relevant to the Affective Guide. Chapter 3 has three important focuses: firstly, it reviews existing emotion literature where theories and models of emotions are presented with the emphasis on bridging the gap between higher-level and lower-level models of emotion; secondly, it investigates emotional memory; finally, it explores some of the existing work on facial expressions. Chapter 4 provides a review of the literature of emotional influence on beliefs in addition to our proposal of the relationship between ideology and emotions.

Chapter 5 surveys tour guide experiences, presents an overview of the Affective guide and details the user interaction interface. It also provides a description of the navigation sub-systems. Chapter 6 proposes our guide's body-mind architecture, the emergent model of emotion that includes the emotion model, a story-telling system and the emotion expressor. It exposes the internal algorithms and mathematical functions involved in the operation of this architecture. Additionally, it demonstrates the relationship between emotions and beliefs in our guide's internal processing. Both Chapter 5 and Chapter 6 provide the implementation details of the Affective Guide.

Chapter 7 provides a simulation of the guide's internal regulation and deploys an experiment which investigates whether the Affective Guide improves users' tour experiences. It also shows results from the experiment followed by a discussion of these results. Chapter 8 offers the overall conclusion, summarises what has been achieved and gives possible directions for future work.

Appendix A presents the data collected during the survey on tour guide experiences. Appendix B and Appendix C provide sample basic story elements and emotional story elements used for narrative construction. Appendix D lists the rules for story extension. Appendix E exposes the data used to simulate the behaviour of the Affective Guide. Appendix F shows a summary of the pilot test results. Appendix G gives the complete list of questions asked to participants in the experiments. Finally, Appendix H provides an electronic version of the complete evaluation data, including a summary of the participants' comments on the Affective Guide system and their subjective opinions about the guide's arguments during the tour.

Chapter 2

Tour Guide Systems

Live as if you were to die tomorrow. Learn as if you were to live forever
- *Mahatma Gandhi. Indian leader, 1869-1948*

Know where to find the information and how to use it - That's the secret of success
- *Albert Einstein. German-American physicist, 1879-1955*

Do not go where the path may lead; go instead where there is no path and leave a trail
- *Ralph Waldo Emerson. American Poet, Lecturer and Essayist, 1803-1882*

Tourism has driven the development of mobile context-aware applications and the creation of virtual tour guides. So, what is the real reason behind this boom? What are the functions of a tour guide? How does a tour guide impact our tour experiences? In this chapter we first describe the role of a tour guide. This is followed by an exploration of some related work in the area of tour guide systems. We expose the state-of-the-art in mobile and virtual tour guide systems. Finally, we present a review of storytelling systems. All the reviews are carried out with special reference to those that inspired our proposed work.

2.1 Role of a Tour Guide

The tourist industry has become one of the fastest growing sectors in the world. Each country campaigns to attract as many tourists as possible every year. Tourism helps to sell a country abroad at the same time as increasing industry profitability. According to the United Nations World Tourism Organisation Think Tank [1] held in Lisbon, Portugal on September 27, 2006, tourism represents forty percent of all exports of services and has spin-off effects ranging from construction to agriculture and telecommunications, creating quality employment for developing countries. This awareness has led to increased investment in tourism related fields and inclusion of tourism as a strategic element in policies targeting job creation, sustainability and poverty alleviation. The tour guide profession has thus gained popularity and respect. More and more places of interest are providing guided tours whether by real human guides or audio guides. Information accessibility has improved, making heritage available to non-experts.

Travel can be one of life's great teachers, and travelling without a guide can be like watching a movie without sound: you see the story but you do not understand it. A professional tour guide can make a trip extraordinary, be it a guided tour in a museum or exhibition hall; or a guided walk around an outdoor attraction. The incorporation of the guide's opinion and experiences into their narration can generate an engaging visit filled with wonderful insights and experiences. A guide can provide an insider's view of the local community, tailoring the trip to our interests.

Almeida and Yokoi [2003] observed that a human tour guide is expected to provide general information about the tour, highlight curiosities about the attractions or objects, tell stories related to the tour, provide adaptive guidance and engaging storytelling, stimulate visitors' participation and interest, reincorporate information from previous tours and answer the most frequently asked questions about the tour topics. In short, a guide can make a tour more meaningful, help understanding about an attraction, and also foster learning and self-development.

[1] http://www.world-tourism.org/newsroom/Releases/2006/september/think_tank.htm

2.2 Tour Guide Systems

The growing research on context-aware tour guide systems to provide guidance to users during a tour visit is part of the effort of ubiquitous computing to integrate computation into environments to enable people to interact with information in an inherently social manner. As opposed to the term 'guide', some tour guide systems at present provide supportive rather than directive functionalities. Context-awareness refers solely to location-awareness for some systems, whilst for others it may include factors such as spatial distances and the user's interests, hence allowing personalisation of information. Some groups demonstrate the employment of lifelife characters, others utilise multimedia presentation techniques, some others use a map-based interface, and some use a combination of all.

In the following section, the existing tour guide systems have been divided into two main categories: mobile guides versus virtual guides. All mobile guide systems involve solving the problem of finding the user's location. The main concern is over the accuracy of the devices used to detect the user's location in the natural environment. These systems are compared based on whether they personalise tour content, whether they are directive or supportive, whether they employ a lifelike character and the types of presentation techniques they adopted. The different input/output interaction mechanisms are also exposed.

On the other hand, all the virtual guides investigated generate personalised information, provide supportive functionalities, are character-based and perform multimedia presentations. The focuses of the review of these systems are on the personalisation techniques and the lifelike characters. Evaluations on the performance of the lifelike characters are discussed and implications are drawn. Despite the variation between all these tour guide systems, one common aim can be distinguished; that is, to acquire and utilise information about the context of a device to tailor services and information for the tourist, situation, place or time.

2.3 Mobile Tour Guides

2.3.1 Non-Character-based Systems

Cyberguide

The Cyberguide project [Abowd et al., 1997], started in 1995, was one of the early investigations on how mobile computing could assist in exploring physical spaces and cyberspaces. It was a series of prototypes of a mobile, hand-held location-aware tour guide, where the tour guide plays the role of cartographer (map component), librarian (information component), navigator (positioning component) and messenger (communications component). The prototypes were developed for indoor and outdoor use on a number of different hand-held platforms.

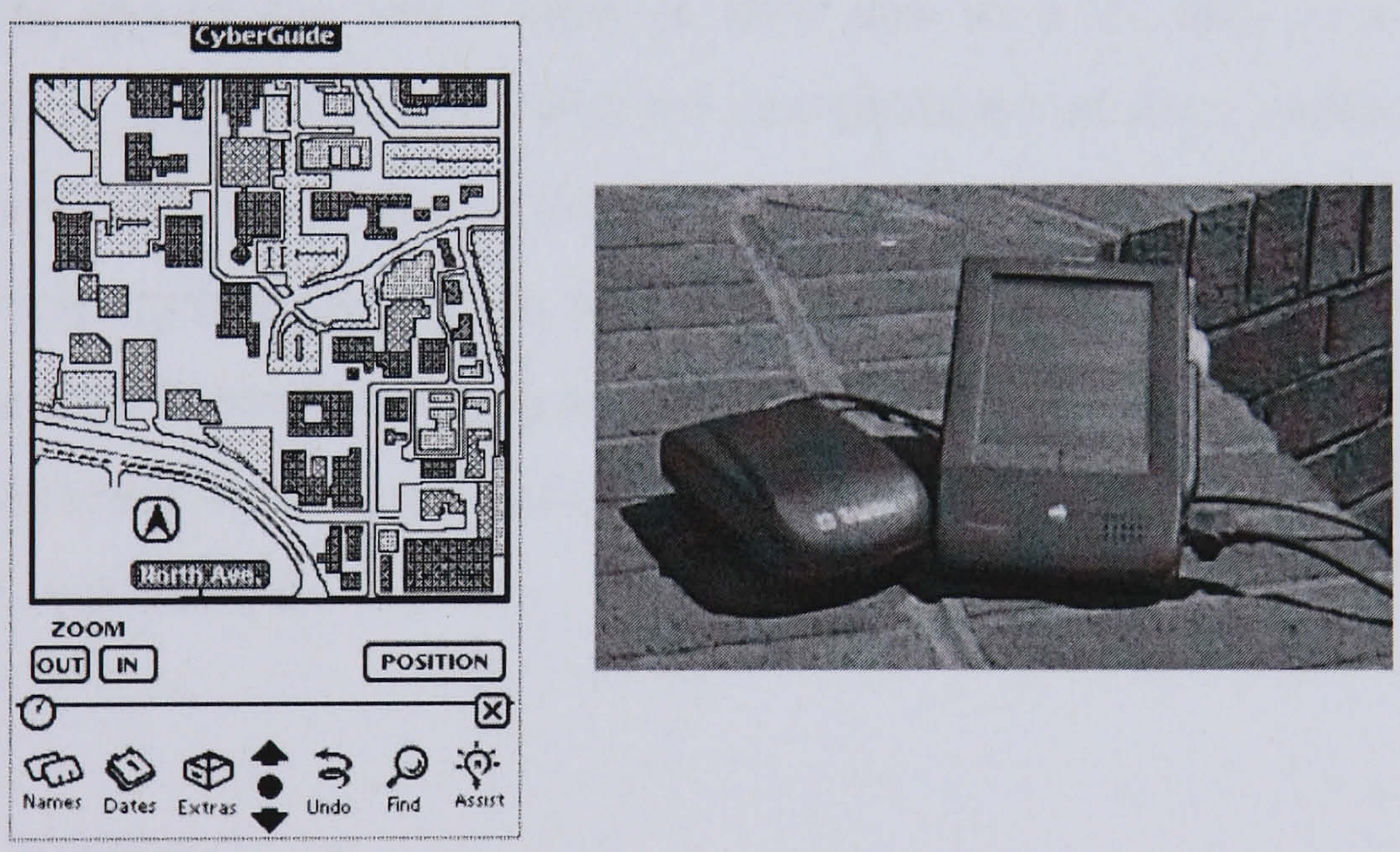


Figure 2.1: The outdoor Cyberguide with GPS unit (from Abowd et al. [1997])

The initial prototypes were meant for indoor use, guiding the user during Georgia Tech open days, where infrared tracking was adopted for positioning. Only a limited view of the space can be seen on the map interface at any given time. Passageways, demonstration stations and visited demos were marked using different symbols on the map with automatic scrolling to ensure that the user's current position remained visible at all times. These prototypes were then extended for outdoor application where GPS tracking acted as a substitute for the infrared module. Pen-based PC versions of Cyberguide were developed and vector-based maps that allowed for arbitrary scaling and rotation of the map as well as path generation were used. This new version recorded the visitor's interaction history to generate a summary of the day's visit, which was later mailed off to the visitor. The next prototype, CyBARguide allowed the tourist to indicate a desired destination and add destinations that were not currently highlighted on the map. Each establishment had a user modifiable database entry allowing them to add comments on the exhibits.

The context awareness achieved by Cyberguide only detected the user's physical location and crude orientation, without taking into account their interest or their reaction to the exhibits, which are important to the overall tour experience and knowledge acquisition. Cyberguide did not perform route planning or direction guiding and let the user wander on their own with the map as a reference. This can be a problem to users who are not proficient at map reading. Hence, direction and orientation instructions are essential to a tour guiding system. In all of the Cyberguide prototypes, all information is carried locally which should not be the case because carrying all information on the PDA can lead to problems, considering limited on-board resources. Additionally, the systems do not customise tour content.

MARS

The Mobile Augmented Reality System (MARS) [Höllerer et al., 1999a] is a testbed that employs four different user interfaces (UIs): an outdoors UI, a hand-held map UI, a desktop UI and an immersive AR UI to allow outdoor and indoor users to access and manage real world spatial information, combining augmented reality and mobile computing as shown in Figure 2.2. MARS supports text, audio, static images, video, 3D graphics, 360 degree surround view images, Java applets and hybrid UIs. Two prototypes have been developed for the outdoor user, a campus tour [Feiner et al., 1997] and a journalistic storytelling system [Höllerer et al., 1999b], applying the concept of situated documentary that relies in part on the idea of creating hypertextual links between physical and virtual objects or locations. Centimeter-level real-time-kinematic GPS, an inertial/magnetometer orientation sensor and a backpack computer system are utilized.

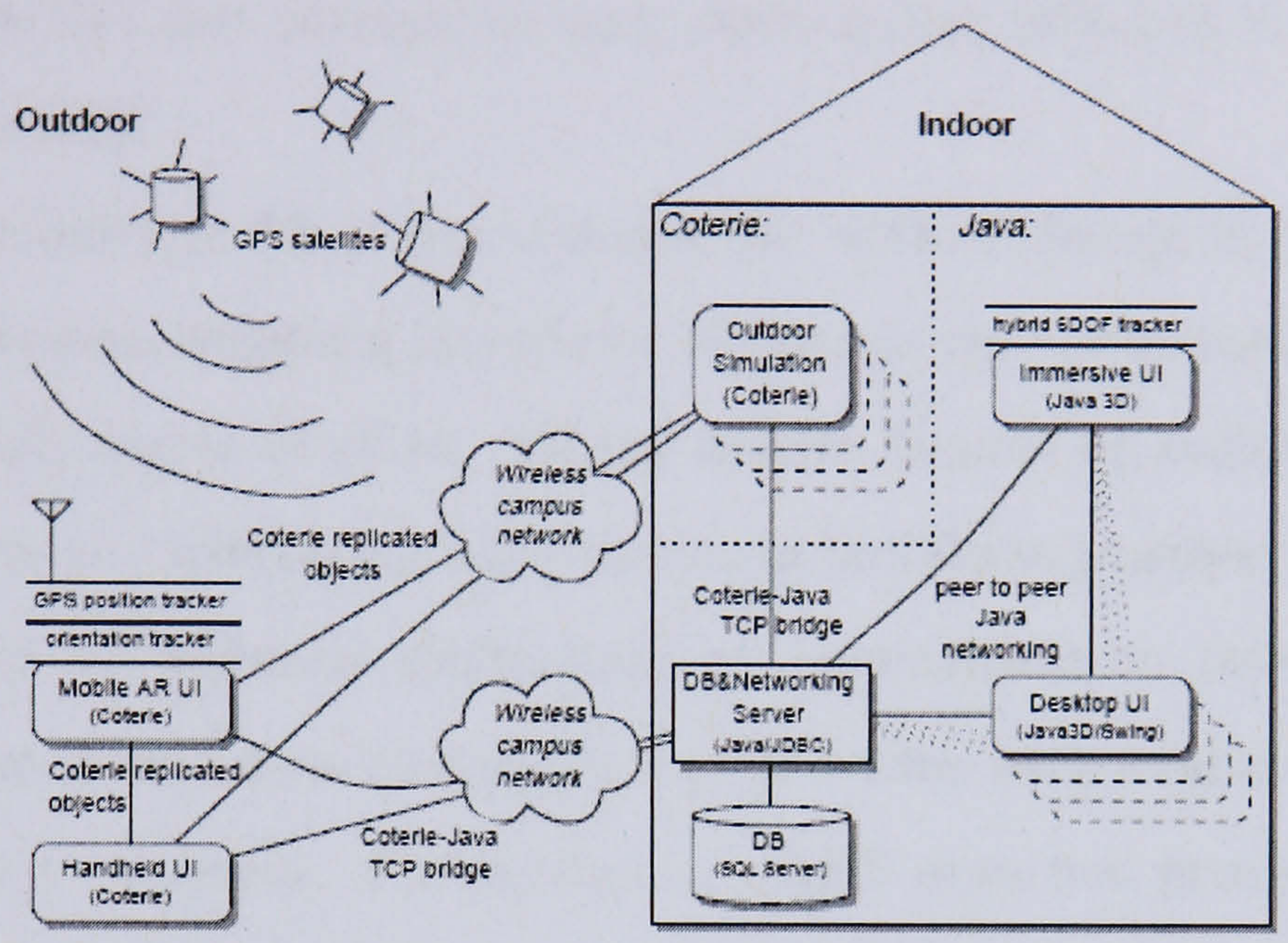


Figure 2.2: MARS Architecture (from Höllerer et al. [1999a])

For the outdoor UI, the user is restricted to the area within range of the local base station for the GPS system, covered by the wireless communication infrastructure and represented within the 3D environment model. The multimedia presentation of this spatialised data takes place using a head-tracked, see-through, head-worn display used in conjuction with a hand-held computer, networked to the backpack computer. The head-worn outdoor UI consists of world-stabilized items, which are visually registered with specific locations and displayed accordingly to the user's perspective and screen-stabilised items, which are fixed to the display and are always visible. A set of selection mechanisms based on positional proximity and gaze orientation, a trackpad for the head-worn display and a pen-based UI for the hand-held allows interaction.

The hand-held map UI can be used in conjuction with the outdoor UI or standalone, while the desktop UI presents information in multiple windows. In contrast, users of the immersive AR UI wear see-through head-worn displays tracked by a 6 degree of freedom tracker and the input devices are wireless trackballs tracked by wireless position sensors. Adopting these UIs, the authors claimed that indoor/outdoor communication and collaboration is possible as indoor users can get an overview of the outdoor scene and communicate with outdoor users through a desktop UI or immersive AR UI. New virtual objects can be introduced by any UIs and changes in their position are reflected in all participating UIs automatically.

Here, the outdoor UI is our concern but with a change in the devices used. The MARS system weighing just under 40 pounds cannot be easily carried around without a high degree of effort. Whilst MARS focuses on collaboration between multiple users and overlaying 3D graphics in mobile augmented reality with high priority given to technical realisation, we concentrate on providing intelligent context-aware information to a single user at a time with a minimum requirement for computing resources. Furthermore, MARS does not provide a directive or personalised tour experience.

DEEP MAP

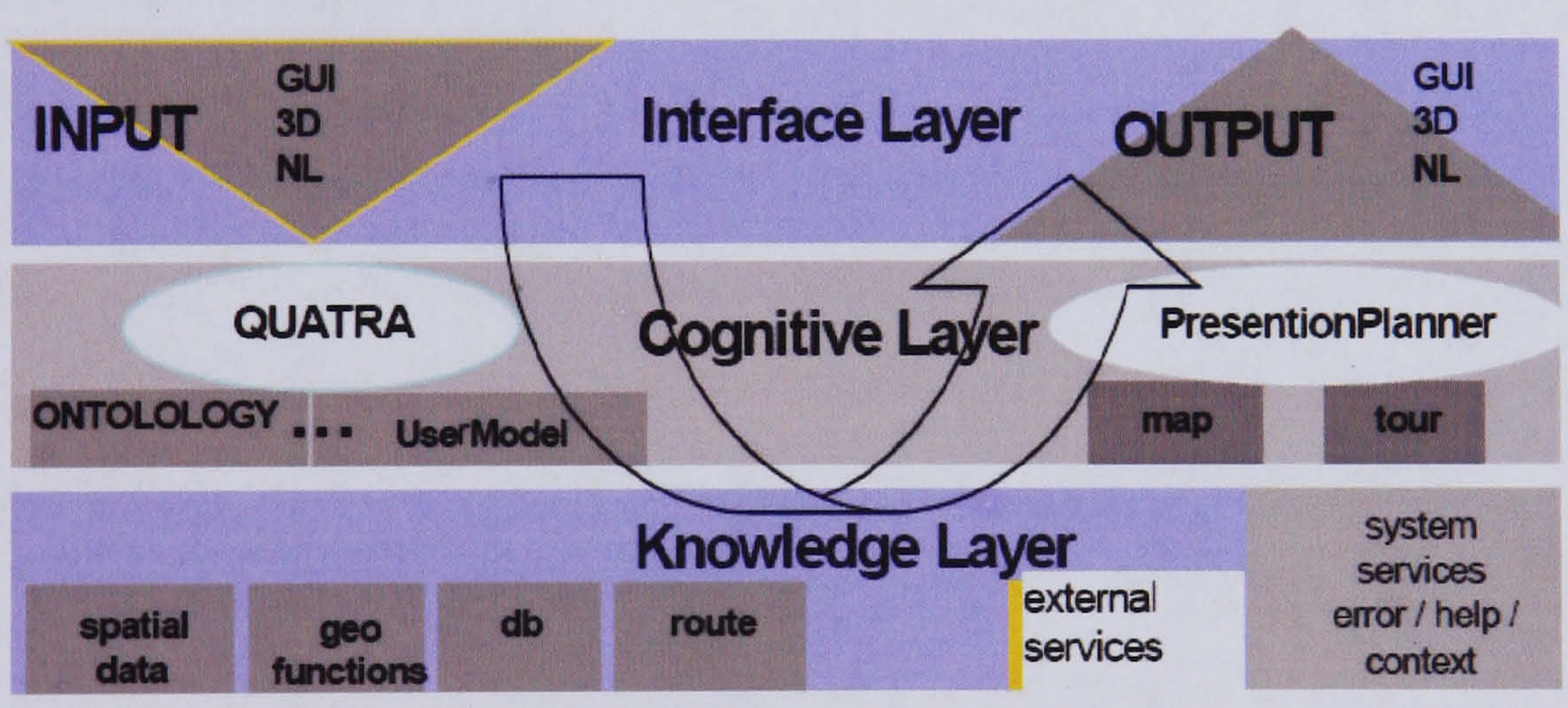


Figure 2.3: DEEPMAP Architecture (from Malaka and Zipf [2000])

DEEP MAP [Malaka and Zipf, 2000], the first research project at the European Media Lab GMBH [2] began in 2000. It proposed a framework aimed at developing information technologies able to handle large heterogeneous data collections, complex functionality and a variety of technologies in a way accessible

[2]http://www.eml-development.de/english/index.php

to untrained users. It incorporated research involving geographical information systems (GIS), databases, natural language processing, intelligent user interfaces, knowledge representation, 3D modeling and visualisation.

Two versions have been considered: a Web-based planning and exploration tool; and a mobile version that uses a wearable computer to allow hands-free usage. The mobile system generates personal guided walks for tourists through the city of Heidelberg and aids tourists in navigation. It takes personal interests, needs, and the social and cultural backgrounds of tourists into consideration when generating the tour. The core of DEEP MAP is a GIS that can handle spatial and topological queries, allowing navigation and route finding. The GIS and databases form the knowledge repository, which are accessed through the database agent, geo-spatial agent, route agent and map agent. The data model for historical geo-referenced data is event-based and information may be translated from 2D to 3D or 3D to 4D (temporal dimension) depending on the tourist's queries. Appropriate variables for the user's interests are included in the database and attached to the locations within the GIS for individual personalised tour proposals. Natural language through speech serves as an important modality for hands-free operation. In contrast, when complex information has to be visualized, a GUI is employed, for example, display of landmark models for easier identification. The cognitive layer translates human concepts into system queries and system responses into human-understandable presentation.

It has to be noted that DEEP MAP was only a framework. The prototype version provided primitive functionalities for a limited area around Heidelberg Castle and did not include all the proposed elements, particularly the tour personalisation facility. The GIS and interactive data sources are not essential to the Affective Guide while others will be simplified. A simple database will be sufficient to hold the Affective Guide's memories. Moreover, there is no need for query facilities since the system will not allow the user to ask questions.

HyperAudio and HIPS

HyperAudio [Petrelli et al., 1999a] and Hyper Interaction within Physical Space (HIPS) [O'Grady et al., 1999] are other innovative systems for delivering context sensitive information to users. In contrast to the above systems, the core element of HyperAudio and HIPS is information personalisation on top of location-awareness. The systems aimed to bridge the gap between physical space and information space. The systems guide visitors in a museum, generating audio messages transmitted through headphones with the aim of integrating the 'physical' experience without competing with the original exhibit items for visitors' attention. A set of relevant links for future exploration and exhibit-related images are displayed on the palmtop screen for pen pointing.

HyperAudio decides what information to present based on the user model, the history of interaction, the discourse strategies and the audio output modality. In modeling the user, it dynamically refines its assumptions on user interests, engagement and level of attention by monitoring user behaviour. The language style is chosen according to the user type and the system includes appropriate use of references to the environment as well as suggesting interesting spots to visit nearby. An infrared receiver is mounted on the headphones and small infrared directional emitters are scattered above meaningful locations in the environment.

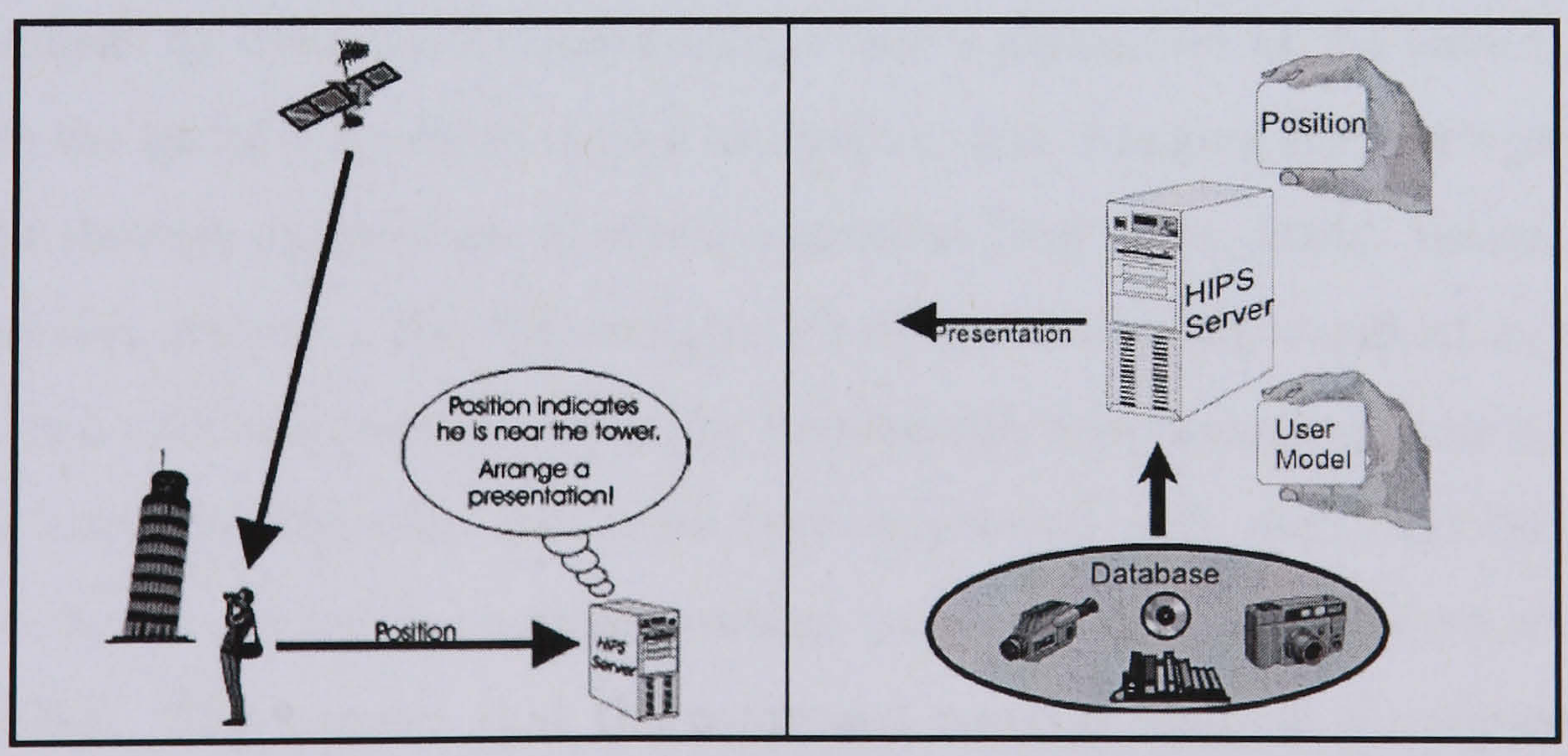


Figure 2.4: HIPS: a) Logical location determination; b) Presentation generation (from O'Grady et al. [1999])

HIPS adapts, personalises and contextualises information delivery based on user data explicitly declared or inferred and location information from a Global Positioning System for exterior or Infrared system for interior position detection. The HIPS architecture adopts a client-server model and can be logically divided into location, presentation, server and data layers. The client supports both implicit and explicit information presentation while the server comprises of a user model, a database and a presentation planner. Implicit interaction occurs when information is presented automatically based on a visitor's location while explicit interaction takes place when the user requests information on a particular exhibit. Interruption of the presentation is possible. Data stored in the database is position-related, the mapping of physical (coordinates) to logical (symbolic) location; and media-related, which can be audio, video, images or text. Each piece of media-related data has an associated logical location that ties it to the physical location. For an effective adaptive presentation, HIPS takes into account the physical environment, the visitor's personal attitude and the visited path, the three dimensions that affect how the visitor is feeling [Petrelli et al., 1999b]. For example, when the user's attention is low, long presentation is avoided. Additionally, M-PIRO [Isard et al., 2003] extended HIPS into non-physical domain, multilinguality and dynamic user modelling based on user stereotypes.

In both projects, multimodality helps to overcome the static constraints of the environment by dynamically changing the user's perception of the environment through the use of augmented reality techniques; and changing the user's physical location through suggestions of where to go next [Not et al., 2000]. Hence, both are directive systems. The Presentation Composer builds personalised and contextualised multimedia presentation by dynamically concatenating atomic pieces of data called macronodes that have been annotated with rhetorical links. It takes as inputs the user's physical position, previous interaction history and the user model. This ensures that the composed message displays a coherent and cohesive structure, a smooth topic flow, references to material already presented, references to user interests and cross-references to environment. Whenever possible, the actual exhibits are referred to by name in the descriptions. Suggestions of the next stop are provided based on the user's interests and the amount of physical effort required to reach the new spot, whilst orientation is supported through language-based messages and images, for example *"On top of the wall ...., opposite the window ..."*.

The GPS acuracy of 50 metres in these systems posed a problem. Futhermore, the authors mentioned personalisation based on the user model, including their degree of tiredness and emotional status, but did not provide explanations on how this information was inferred and how accurate the inference was. A concrete evaluation on the effectiveness of these systems is also lacking. In spite of these flaws, both projects provide an inspiration for adaptive story presentation based on a visitor's feeling and interests.

2.3.2 Character-based Systems

Personification of intelligent interface agents has been mushrooming in recent years. These agents take the form of an animated lifelike character, visually present on the computer screen. Lifelike characters have been shown to make presentations more enjoyable, attractive and engaging [van Mulken et al., 1998] as well as improving the learning experience [Lester et al., 1997]. Whilst none of the above systems employ an interface agent, this section focuses on work involving the application of a virtual character as a tour guide. The story personalisation techniques adopted by these systems are reviewed.

C-MAP

C-MAP, Context-aware Mobile Assistant Project [3] [Sumi et al., 1998] started in 1997, is an attempt to build a personal mobile assistant for visitors touring museums and open exhibitions. In addition to Cyberguide and MARS that provide information based on visitors' locations, it takes into account individuals' interests. Furthermore, it introduces an interface agent for interaction with the user. The project aims to investigate computer augmented environments that enhance

[3] http://www.mic.atr.co.jp/dept2/c-map/index-jp.html

communications and information sharing between people and knowledgeable machines.

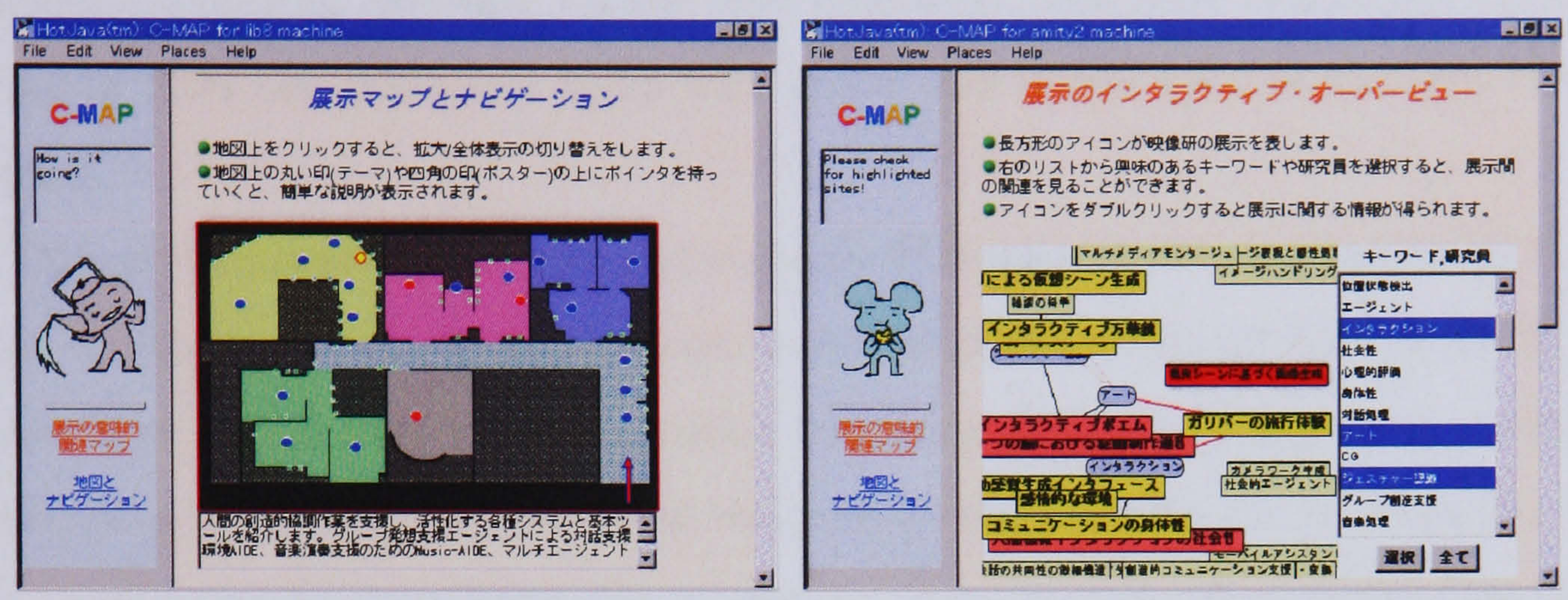


Figure 2.5: C-MAP User Interface (from C-MAP website)

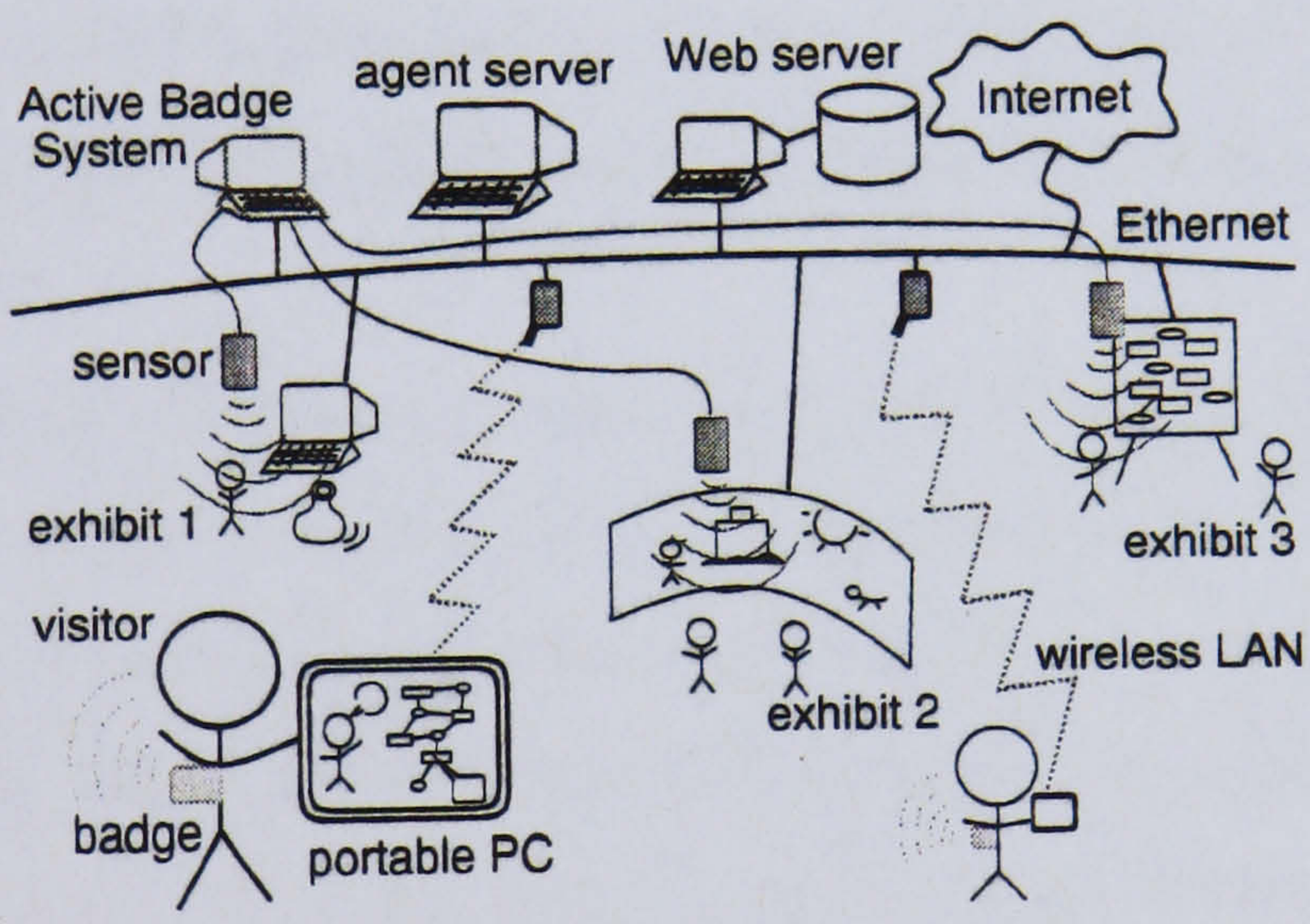


Figure 2.6: C-MAP Architecture (from Sumi et al. [1998])

The interface agent is presented by an animated applet using GIFs with a text message box on a mobile computer. It guides users using two exhibition maps, which visualize the geographical and semantic information of the exhibition space as illustrated in Figure 2.5. The keywords that the user selects modify their interest vector and affect the restructuring of the semantic map and the agent's recommendation of exhibits. A template of the interest vector is employed for the first time user. The animated character expresses the internal state of the guide agent, draws the user's attention to exhibits, hurries the user to the next site when necessary, and informs about system usage. The project also facilitates information sharing amongst visitors and exhibitors who have shared interests during or after the exhibition tours with onsite and offsite services through the Internet.

The system consists of servers and portable PCs connected by a wireless LAN, which further connects with the Internet as well as an Active Badge System (ABS) [Want et al., 1992] used for user location detection. The internal process of the guide agent is performed in the agent server and each portable PC runs the HotJava browser for Java applets to guide the tour, show exhibit-related information, interact with the user, and display the animated characters. It is possible to combine the C-MAP's mobile assistant with exhibit applications to provide seamless guidance in a virtual world based on the real-world context. An experimental system, the VisTA-walk [Kadobayashi and Mase, 1998] utilises Computer Vision technology to allow users to walk through and access information in 3D virtual spaces with gestures.

Although portable PCs have an advantage over PDAs in that they have a wider visualisation screen, they are heavy and inconvenient. The ABS failed to monitor more than 6 sensors and badge detection by the sensors was found to be unstable. Besides that, C-MAP lacks voice guidance requiring head-down interaction. Futhermore, receptionists are required to help the users in registering their information into the system. Each animated character possesses only four actions and several corresponding messages - suggesting, thinking, hurrying and idling, which it switches according to its internal state. Hence, after a few interactions, repetition occurs, which can be annoying in the long run. There were neither effective in representing the agent's internal state nor useful for improving the agent's reliability.

However, an interesting finding by C-MAP researchers was that, although the animated character has only simple states, it does provide the user with a feeling of intimacy, which implies that the agent does not need to have a complex architecture to be believable. In other words, the agent should not have more states than necessary. Another useful finding by C-MAP researchers is that web surfing was rarely observed during the tour as the actual exhibits are in front of users.

The GUIDE

The GUIDE [Cheverst et al., 2000] is an intelligent electronic guide for use by visitors to Lancaster. It is based on a distributed and dynamic information model. It uses a cell-based wireless communications infrastructure for data dissemination to multiple hand-held GUIDE units. The positioning information is obtained by receiving location messages that are transmitted from strategically-positioned base stations. A purpose-built information model is designed to represent geographical information, hypertext information and active components that can react to events.

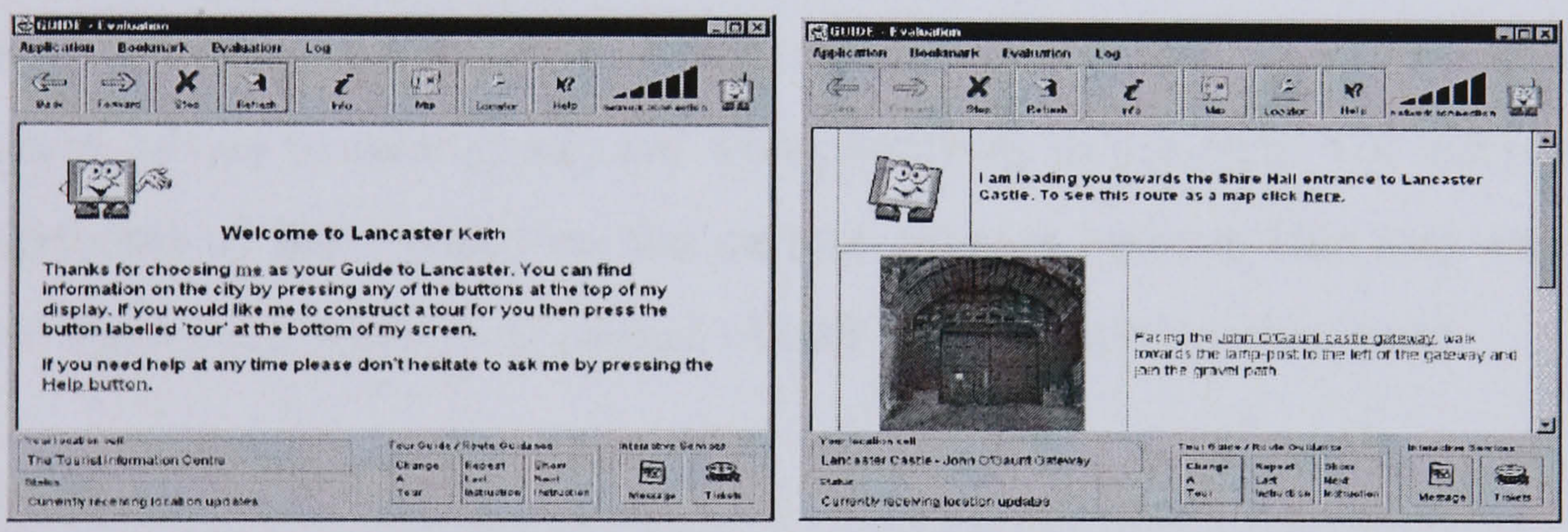


Figure 2.7: a) The GUIDE Welcome screen b) The presentation of navigation information (from Cheverst et al. [2000])

Parts of the information model can be cached in each of the GUIDE units to ensure continuous operation when it is disconnected from the network. However, if the period of disconnection is too long, information becomes out of date and the system behaviour appears unpredictable. Hence, the state of connectivity is shown on the user interface to provide visitors with an awareness of the state of location updates. The GUIDE provides facilities for information retrieval; navigation around the city using a map; creation and then following a tour of the city; communication with other visitors or the Lancaster Tourist Information

Centre by sending text messages; and booking of accommodation. Information available can be both context-sensitive and non-location specific. The system tailors its tour to opening and closing times, the best time for a visit and the distance between attractions, without continuously adapting the presentation to the user's interest.

Its evaluation argues that there should be an animated feedback to signify when a page is downloading, the presentation order of attractions should be adaptive, there should be a notion of how much information is still to be viewed and there should not be any ambiguous metaphors or buttons on the common interface. Its interface provided too many functions that create confusion and information overload in users. The authors also discovered that interaction with a context-aware system is not affected by the design of the user interface alone, but is also governed by the design of the infrastructure, for example network connectivity. These results imply that a simple interface and a reliable and responsive system are essential to encourage usage. Designers of context-aware applications are given advice to take great care when deciding to pre-empt the information requirements of users based on the current context because this may result in visitor frustration when they cannot obtain the information they want.

PEACH

PEACH, Personal Experience with Active Cultural Heritage [4] [Stock and Zancarano, 2002] is a project to enhance the appreciation of cultural heritage through the development of a personal guide, featuring a lifelike character that can accompany an individual during a museum visit and subsequently adjust the delivery of information to the visitor's interest. The project was designed to link the physical space with the information space and envisions a remote and interactive appreciation of cultural heritage by means of an accurate virtual reconstruction of the object.

PEACH focuses on natural interactivity and microsensory systems. It is a synergy of various technologies including software technologies for multimedia

[4] http://peach.itc.it/home.htm

distributed systems using cinematic techniques [Zancarano et al., 2003], adaptive and proactive technologies for contextualized presentations, speech interaction for children, acoustic technologies, vision technologies and sensors for 3D vision. It uses augmented reality techniques adopting a palm computer for exploration and infrared technology to locate the users throughout the museum. Personal PDAs are also combined with a Virtual Window acting as public broadcast device that provides the visitors with in-depth information on interesting topics [Kruppa, 2004]. Communication between these devices and the server is realized with standard wireless LAN technology.

Initially, the system finds topics which are of special interest to the user simply by dealing with exhibits that the user has visited. Goren-Bar et al. [2005] found that the major requirements for an affective interface based on a delegation of control would be a system that is autonomous, enables the visitor to easily express their feelings and has a transparent adaptive capability. Hence, the most current version of PEACH provides a 'like-o-meter' with five degrees of liking for the user to express their feelings and the results of predictions are reflected to the user using the same meter.

Figure 2.8: PEACH interface (from Goren-Bar et al. [2005])

While PEACH is a large research project that involves a great deal of human effort, the Affective Guide is a simpler version of it, taking advantage of features such as delegation of control and the 'like-o-meter' concept for user input. By giving the users an appropriate amount of freedom, they will feel that they are in control of their experience and that the guide cares for their needs. Moreover, a guide that shows adaptive behaviour is likely to be perceived as intelligent and believable. Although PEACH takes into account the user interest for presentation generation, it does not incorporate the guide's interests as a real tour guide does.

2.4 Virtual Guide Systems

Tour guide research has also been carried out in the area of virtual environments. As mentioned earlier, all the virtual guides reviewed generate personalised information, provide supportive functionalities, are character-based and perform multimedia presentations.

2.4.1 Online Museum Exhibition

Figure 2.9: a) Beginning of the tour b) Screen of the Pilot room (from Almeida and Yokoi [2003])

Almeida and Yokoi [2003] attempt to shape dialogue interactions between an interactive conversational character, and the user in a guided tour to an online virtual exhibition of a XVI century Portuguese ship. The virtual tour guide system is made up of two components: a keyword spotting program with a natural language processing system that delivers pre-scripted statements from a knowledge-content database and a MS-Agent [5] character that presents the statements using gesture-choreographed dialogue pieces. The user's input is typed into a textbox, whilst the guide's remarks are delivered through text balloons and audio output.

The tour guide knowledge-content database stores dialogue steps, keywords, pre-conditions for dialogue piece delivery and the tour-guide personal history and mood setting. By using the pre-condition features, the guide can personalize the dialogue, avoid repeating information and trigger extra stories. The ability to arrange keyword schemes allows the tour guide to make some 'intelligent' references, for example, *food* will lead to firing of *biscuit, bread, lunch, eat.* The guide detects the user's interest in an indirect way by recognizing supportive words during interaction and through the user's questions.

The user evaluation showed that communicating or interacting with the virtual tour guide character was enjoyable and the tour guide was effective in motivating users to explore and learn more about exhibition topics. However, users hardly recognized the ability of the character to provide further information when they were interested. The guide's knowledge database needed expansion and a personal introduction could be useful as an ice breaking tool to engage the user's interest. This system tried to personalise information but did not expose adaptive behaviour during the interaction. Due to its limited knowledge, the guide often did not understand the users' questions leading to their frustration. These results indicate that a lifelike character must have sufficient intelligence in order to maintain interest and reduce frustration in the user.

2.4.2 SAGRES Virtual Museum

The SAGRES system [Bertolleti et al., 2001] is a virtual museum that seeks to build a new educational environment by providing information available in the museum through the web. The system determines the information appropriate to the visitor and shows it in a resultant HTML page. The artefacts are arranged in the system in agreement with their actual location, allowing the visitor to easily

[5] http://www.microsoft.com/msagent/default.asp

find them in a real visit. The information can be accessed in several ways and the system supports different groups of users: visitor, teacher and student.

Software agents, represented as animated characters were used to incorporate personal assistance for SAGRES's users to ensure that they do not get lost during navigation, due to the large number of links available. They can provide assistance during systems operations and can execute tasks on the users' behalf. They are also quite useful in analysing and monitoring the users' actions. The agents can improvise behaviour and have different possibilities to perform the selected behaviour making them more flexible, life-like and believable, increasing the users' satisfaction with the system operation. The system identifies and loads the user's model based on user name and password and subsequently builds the presentation according to the user's selected subject.

Similar to Almeida and Yokoi's findings, user evaluation verified that the personal assistant was indeed an important aid to visitors, helping and motivating the exploration of information and the operation of the system. Their human-like behaviour offers user a more friendly interaction interface, increasing the attractiveness of the system. This suggests that the addition of flexible behaviour to the guide agent gives it a personality that will increase the suspension of disbelief in users, and at the same time help them to learn and encourage them to explore for more information.

2.4.3 Kyoto Digital City Tour Guide

The Kyoto Tour Guide [Doyle and Isbister, 1999] project, developed in conjunction with C-MAP (see Section 2.3.2 above), has four main components: 3-D explorable tour sites; a database of gesture-choreographed site-related stories, which are performed by a Microsoft Agent[6]; a commercial chat server; and an agent that drives the tour and the performance of the Microsoft Agent. This system is comparable to the Online Museum discussed in Section 2.4.1. The database includes three versions of each story: short, medium and long to be

[6]http://www.microsoft.com/msagent/default.asp

delivered depending upon the level of user interest and activity during the tour. The current implementation of the tour agent tracks the quantity of conversation and looks for positive and negative keywords that indicate how visitors feel at that moment, and selects stories based on a very simple decision rule. For example, a short story is presented when negative keywords implying low interest are detected. These simple rules would be useful to the Affective Guide system.

The Kyoto Tour Guide did not adapt storytelling based on user-specific topic interests but merely based on their current interest level. From the experience of this project, the authors suggest four traits that are critical for creating believable and compelling tour guides. These traits include intelligent reincorporation; empathy with content; presentation through personality; and artful timing or delivery of presentation. These findings further confirm our argument that emotion and personality are essential for the creation of an engaging and interesting guide. Additionally, attention will be given to reincorporation of stories and timing of delivery to ensure that stories always relate to what is in sight at any given time.

2.5 Other related work

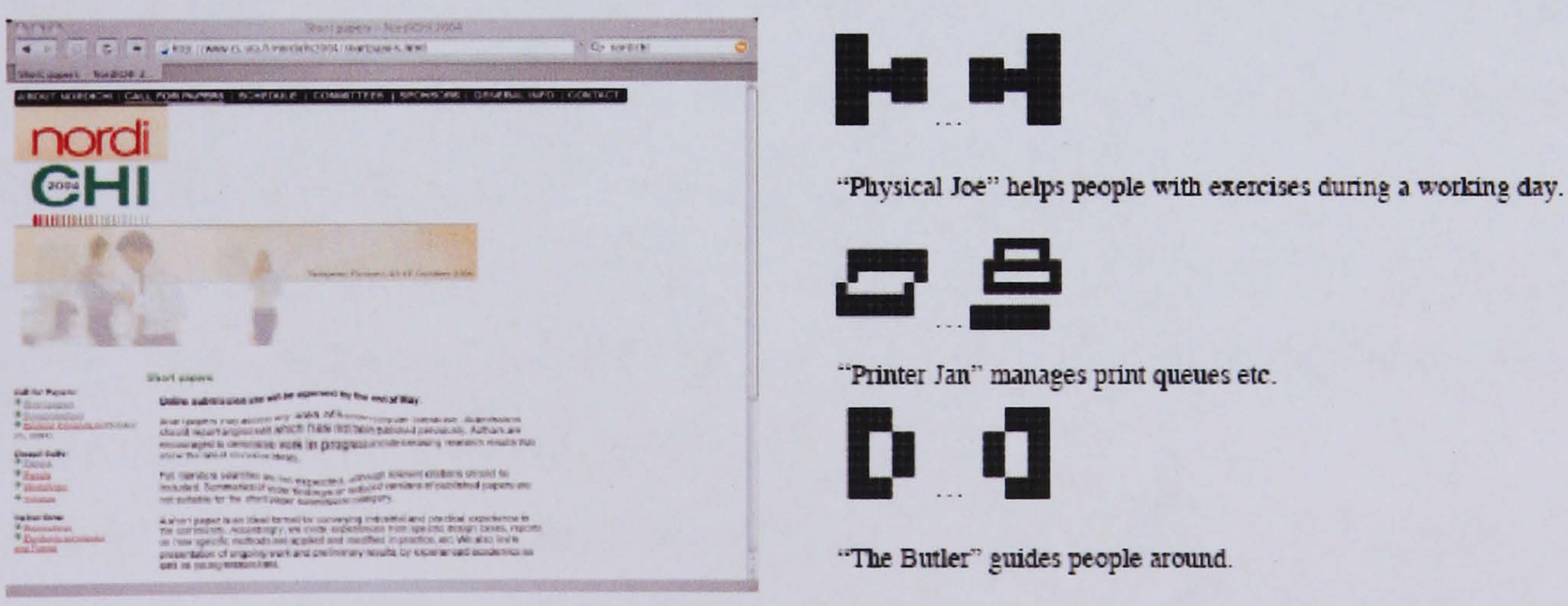


Figure 2.10: Ghost Wake and Animated Ghost Icons (from Hartmann [2004])

The DELCA (DisEmbodied Location-specific Conversational Agents) Ghost Project[7] [DELCA, 2004] is a project by the IT University, Copenhagen (ITU) that

[7]http://delca.itu.dk

aims to achieve high quality agent based assistance without demanding visualization requirements. The authors believe that conversation is the most efficient modality for interfaces when comparing the information processing and bandwidth capacities needed. The notion of ghosts (disembodied and revealing/hiding themselves unexpectedly) provides features that are heuristically very interesting for developing pleasant, interesting and functionally satisfactory agent-based assistance, at the same time keeping the technical requirements to a minimum. The lifelike interface character has been replaced by two discrete visualisation techniques, Ghost Wake and Animated Ghost Icons [Hartmann, 2004], shown in Figure 2.10.

Functionally, the DELCA ghosts provide a range of different types of assistance such as guidance, context specific assistance, security checking, logging and monitoring, introductory services and as participants in location-based interactive events. Technically the skeleton of the DELCA ghosts is the context sensitivity provided by a positioning system comprising densely distributed WLAN base stations and a server for locating every WLAN equipped mobile device. A speech recognition system was employed and interaction takes place mainly through conversation mediated by microphones. This project concentrates on providing assistance in daily activities instead of during a tour visit. Each of the ghosts has a different role and personality resulting from their past life, and performs a different task, hence each resides in a different location at ITU. The DELCA project shows that the Affective Guide system does not need to apply all modalities at all times, reducing the technical requirements. Speech is sufficient most of the time unless text or images need to be displayed.

In terms of presentations personalisation, ILEX [O'Donnell et al., 2001], a dynamic hypertext system which allows exploration of objects in the National Museums of Scotland's 20th Century Jewellery Gallery, modelled the user's interests, the system's interests, and the contextual relevance. The user has the freedom to explore any personalized information object at will, however, the descriptions produced are constrained by the system's own agenda of educational goals. Extending ILEX, SOLE [Hitzeman et al., 1999] embedded ILEX's functionalities in an audio-guide enviroment. It aimed at providing a general interface between natural language generation and text-to-speech systems. By coupling these two systems, it allows the presentation of personalised text by means of spoken language. On the other hand, M-PIRO [Isard et al., 2003] concentrated on highly personalised multilingual information delivery in virtual and other museum settings. It modelled three languages (English, Greek and Italian) from the same source representation and tailored information presentation dynamically according to the user's personal profile (a child, an adult or an expert) and interaction history.

Other guidance systems or location-based systems include the REAL project [Baus et al., 2002], Mobile Reality framework [Goose et al., 2002], Meta-Museum[8] [Mase et al., 1996], Ubiquitous Talker [Nagao and Rekimoto, 1995] and Tourguide[9]. Robot guides are also available including MINERVA[10], TOURBOT[11] [Trahanias et al., 2005], Sage [Nourbakhsh et al., 1999], Zaza[12] and RobotX[13].

2.6 Storytelling Systems

A tour guide should provide interesting stories to encourage learning so as to create a meaningful tour experience. This section exposes the storytelling systems that inspired our research.

Terminal Time[14] [Domike et al., 2002] is a history engine that combines historical events, ideological rhetoric, familiar forms based on TV documentary and artificial intelligence algorithms to construct custom-made historical documentaries for mass audiences taking into account the audiences' polls. The system utilises questionaires as the user interface and an applause meter measures the audience reaction to the possible answers to each question. The computer program

[8] http://www.mic.atr.co.jp/ rieko/MetaMuseum.html
[9] http://www.applesound.co.uk/tourguide.htm
[10] http://www.cs.cmu.edu/ minerva/
[11] http://www.ics.forth.gr/tourbot/
[12] http://www.praecogito.com/ brudy/zaza/
[13] http://www.bluebotics.com/entertainment/RoboX/
[14] http://home.earthlink.net/ steffidomike/tt/TT.html

creates historical narrative that strongly emphasizes the audience's ideological preference, with the history unfolding based on the winning choice. The engine, shown in Fig 2.11 uses multimedia material covering the past 1000 years of world history as the source for narrative construction. This system addresses questions concerning the relationship of perspective to the construction of history.

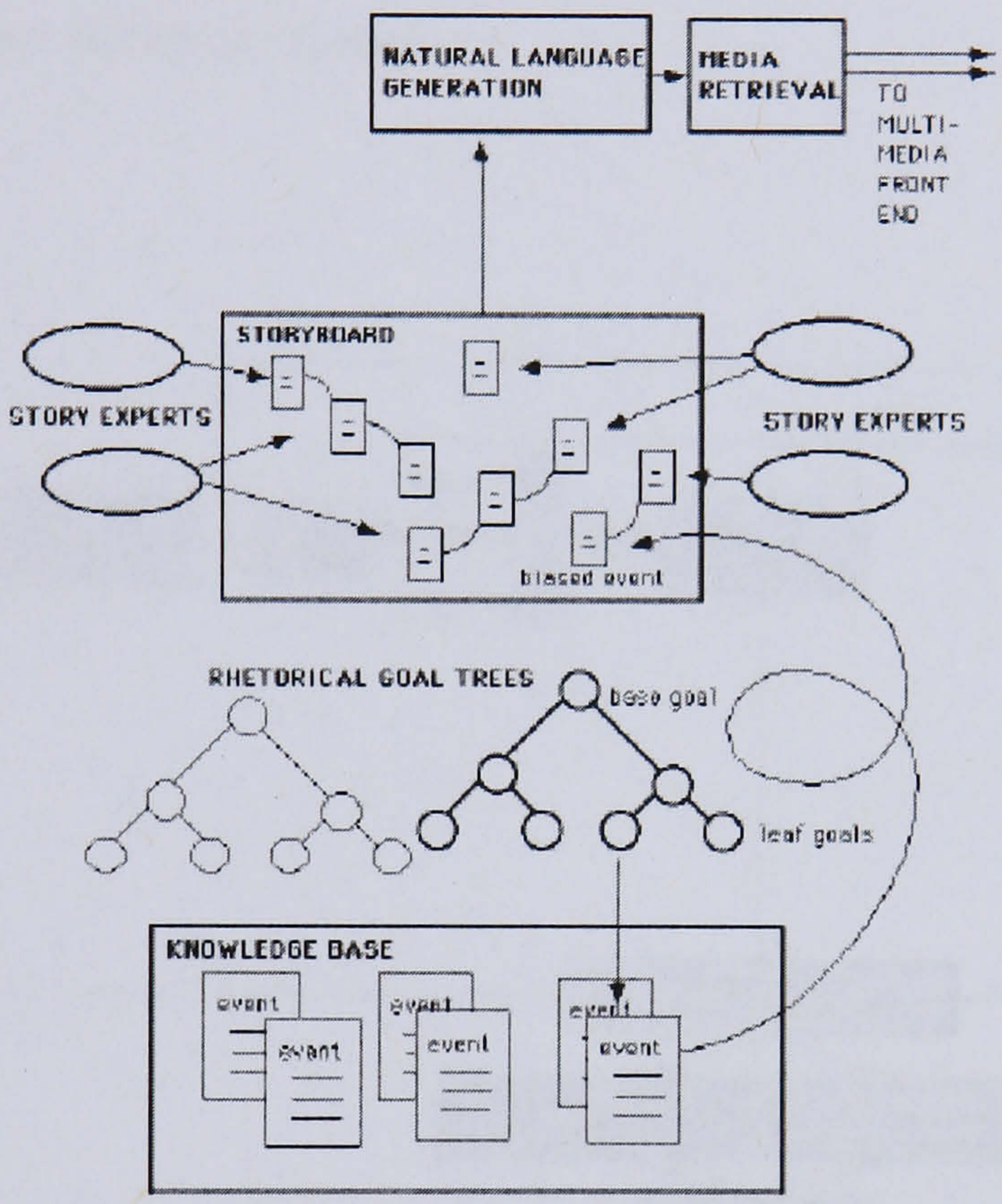


Figure 2.11: Terminal Time Architecture (from Domike et al. [2002])

Instead of trying to reconstruct alternative long views of history based on ideological biases, we attempt to make the users aware of the availability of different ideological perspectives on a specific historical event. Whilst Terminal Time generated stories in response to audiences' generic ideological viewpoints, we take into account both the user's and the guide's interests. Our system adopts improvisational story generation based on a variety of factors (discussed in Section 6.2.1) rather than following a pre-defined storyline in support of a winning ideology.

Ibanez [2004] proposed a story generation agent that can generate short stories using inference rules that combine historical facts and common-sense knowledge. At each step, the guide decides where to go and what to tell dynamically. This system constructs stories by improvising, taking into account factors such as the distance from the current location to a destination, the already told story at the current moment and the affinity between story element and the guide's profile as illustrated in Figure 2.12. Three scores corresponding to these factors are calculated each time, which are then combined to calculate an overall score for each candidate pair of story element and location. Finally, the pair with the highest overall score value is chosen.

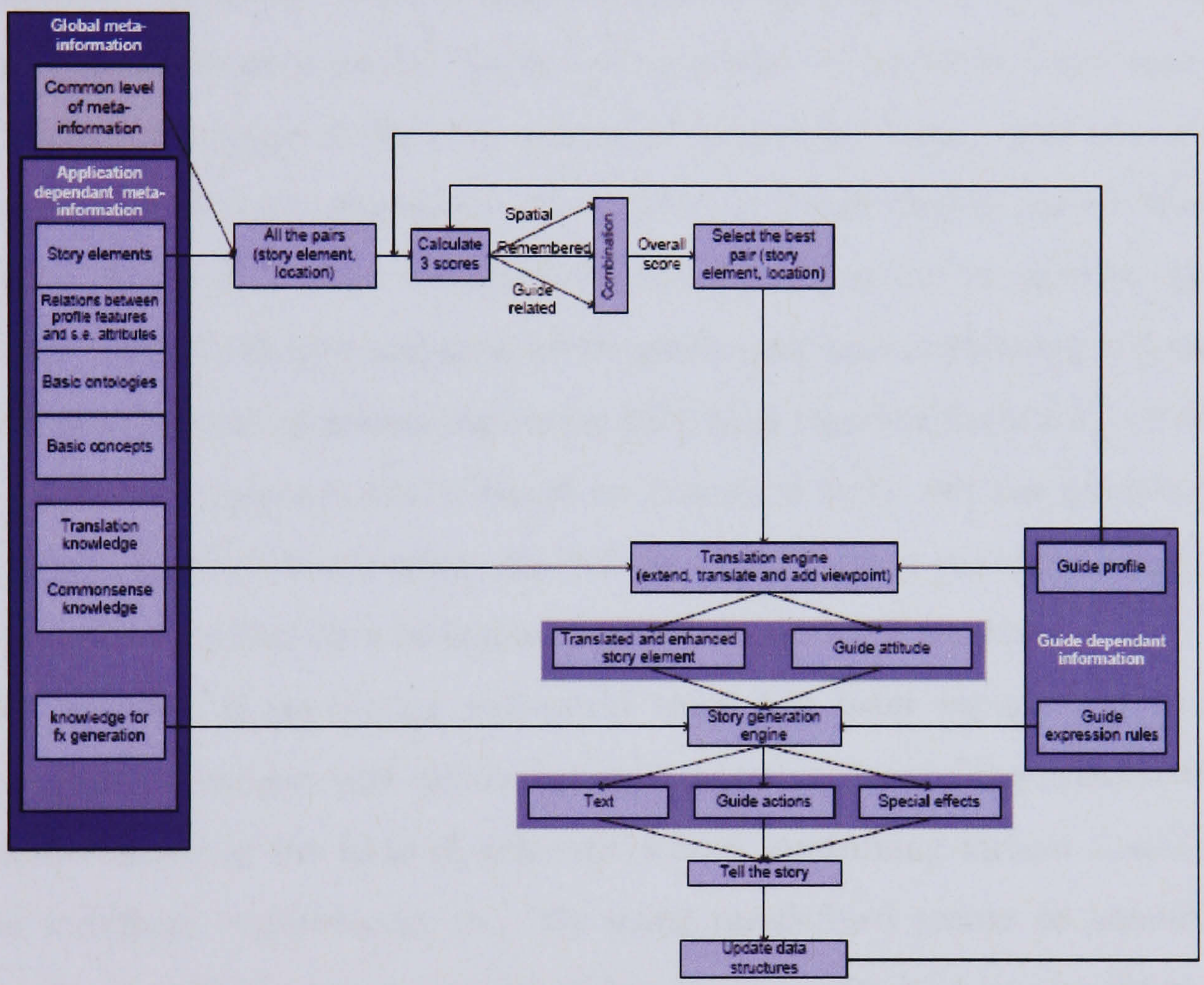


Figure 2.12: Ibanez' story construction algorithm (from Ibanez [2004])

If the granularity of the selected story element is not large enough to make a story of acceptable length, more story elements are selected. These elements are then translated from the virtual guide perspective, incorporating the guide attitudes that reflect the emotional impact on it of these story elements. Next, the story elements are enhanced by means of new information items generated by inferences from simple common-sense rules. Hence, the guide selects the story which fits the current context best and adapts this story to produce a new one from its own viewpoint. It has memories about historical facts and hybrid algorithm is adopted to model its behaviour.

Generating narrative from a guide's viewpoint is also the problem we address. Hence, we utilise the approach just discussed. In general, Ibanez's work brings us a step nearer to the creation of an 'intelligent guide with attitude'. It adopts a storytelling technique that links the memory and interests of the guide to their spatial location so that stories relevant to what can be immediately seen can be produced. However, what it lacks is the incorporation of the user's interaction. Whilst Ibanez's system omits user interests, we consider these together with feedback throughout the tour session as important factors that may affect the user's overall tour experience. The Affective Guide makes use of interest attributes attached to story elements and locations that can be used to choose spots that interest the user and thus, allow personalised route planning and tours. While Ibanez' system generates stories by inferences based on facts and commonsense rules, we construct stories based on historical facts and the guide's past experiences. Instead of activating pre-defined attitudes and emotions, our guide behaviour is controlled by a biologically plausible model of emotion.

The problem of generating real-world tours has been explored in Geist[15] [Braun, 2003], a project that developed an interactive storytelling system where stories are stored in the form of dramatic scenes, containing virtual characters, virtual buildings, storyboards, etc. By using pre-defined scenes to handle the virtual characters' behaviour, and by giving scene results back to the Story Engine, it selects the next scene to be played, in relation to the interaction of the user. Within the scenes, conversational interaction is used to permit a humanlike communication with the actors. Conversation is modelled taking into consideration social and emotional factors, story content sequences, immersion, user's perceptual focus, content information and navigational aspects.

In a sense, our proposal deals with the same problem as Geist but we do not model the conversational aspects. Alternatively, a very simple interface for user's feedback is included. Even in Geist, the user interaction possibilities are

[15] http://www.tourgeist.de/

constrained by the pre-defined scenes. While Geist uses a database of explicitly pre-generated stories, our system constructs stories, step by step as in Ibanez's system.

2.7 Summary

From this review, it is very clear that Tour Guide applications are multiplying. All these systems share one common goal, that is to provide the user with context-aware information. Different devices and technologies have been exposed in the discussion of mobile guide systems (Section 2.3). Most of these systems are still constrained by heavy and bulky devices, which will be avoided in the Affective Guide. The global positioning system is found to be most appropriate for location detection as it eliminates the need for base-stations. Interestingly, all these systems except MARS did not address the orientation problem. This is likely to be due to the unavailability of ready-made hardware for easy integration with the current technologies. So, an alternative method that can utilise existing accessible information has to be sought for the Affective Guide

The non-character-based mobile guides discussed in Section 2.3.1 do not provide directive support and do not customise tour content. However, an exception applies for the HIPS and the HyperAudio systems which provide directional suggestions. In both systems, the model of users is built by making assumptions about the user's behaviour, though there is no explicit explanation on how this is done. Additionally, only minimal interactivity is provided by all these systems. There is a lack of 'life' in the interaction process because no human-like communication takes place.

The character-based guides, on the other hand, allow more interesting interaction. Some of the systems are map-based, while others utilise multimedia presentation. The guides take the user's feedback into consideration for personalised information construction. The PEACH system even provides a facility for the user to express their feelings during the tour, an idea applicable to the Affective Guide. However, one thing is missing in all these applications - an affective model for the guide and affective communication from the guide to the user. According to Nass et al. [1994], the individual's interaction with computers are inherently natural and social. Because affective communication occurs naturally between people, it is expected by people when they interact with computers.

Although the character-based guides integrate life-like animated agents, none of the agents possess a real affective model. These agents react to the users actions using pre-scripted statements or different versions of pre-generated stories and different combinations of pre-recorded behaviours in the databases. Hence, their reactions can be quite rigid at times, following the same path, lacking dynamicism in the presentation of information. This dynamicism in interaction forms the heart of the Affective Guide System. The evaluation results of the reviewed systems provide awareness that an interesting and engaging guide needs to have sufficient intelligence, emotions and personality as well as capability to perform storytelling at the right time and place. Therefore, a storytelling system that allows improvisational story generation has been selected. Furthermore, there needs to be a balance of control between the guide and the user.

Chapter 3

Emotion, Memory and Facial Expressions

Courage is resistance to fear, mastery of fear - not absence of fear
- *Mark Twain. American Humorist, Writer and Lecturer. 1835-1910*

You have to begin to lose your memory, if only in bits and pieces, to realize that memory is what makes our lives. Life without memory is no life at all, just as an intelligence without the possibility of expression is not really an intelligence. Our memory is our coherence, our reason, our feeling, even our action. Without it, we are nothing.
- *Luis Buñuel. Spanish director, 1900-1983*

Once you replace negative thoughts with positive ones, you'll start having positive results
- *Willie Nelson. American country western singer*

A mask tells us more than a face
- *Oscar Wilde. Irish Poet, Novelist, Dramatist and Critic, 1854-1900*

3.1 Introduction

Emotions represent an important source of information acting as evaluation mechanisms on performance, filter relevant data from noisy sources and provide a global management over other cognitive capabilities and processes, important when operating in complex real environments [Oliveira and Sarmento, 2003]. Emotions play a critical role in processes such as rational decision-making, perception, human interaction, human creativity and human intelligence [Picard, 1997]. Picard asserts the role of emotions in evaluation and pruning of search spaces. She adds that there is no universal model of responses to a situation but a person's history, values and general emotional maturity combine to influence their cognitive responses. This chapter presents a review of relevant emotion theories, followed by an investigation of emotional memory, deemed important for the tour guide. The related emotional architectures are discussed. Finally, a review of some inspiring work on facial expressions is presented.

3.2 Emotion Theories

As far back as 500 BC in Western European history of emotional theory, emotion was defined in terms of physical states of the human body [Fellous, 1996]. As reviewed in [Fellous, 1996] and [de Sousa, Spring 2003], most of the great classical philosophers - Plato, Aristotle, Spinoza, Descartes, Hobbes, Hume - had recognizable theories of emotion. Plato became the first to propose that soul affects the body and vice versa and presented his three states theory. Aristotle, on the other hand, argued for a physiological basis for emotions introducing the concept of expression as part of emotional experience with the physiology revolving around the concept of Pneuma.

The Post Aristotelian period is notable in attempts at defining and classifying the Passions, where the body is seen as the locus of emotions. Ethics, religion and concerns on how to live the 'best life' dominate the theories of emotion during this period. The Stoics took emotions as judgments about the value of things incidental to an agent's virtue. In the seventeeth-century, Descartes proposed a separation of mind and body. He and many contemporary psychologists posit a few basic emotions out of which all others are compounded. In Spinoza's view, emotions are not lodged in a separate body in conflict with the soul but as affections of the soul, make the difference between the best and the worst lives, while Hobbes assimilated passions to specific appetites or aversions.

Later in the eighteenth-century, David Hume suggested a dynamical view of emotions. His pronouncement that reason is and ought to be the slave of the passions placed emotions at the very centre of character and agency, essential to human social existence and morality. Kant grouped emotions with inclinations enticing the will to act on motives other than that of duty. Surprisingly, the 20th century philosophers of mind and psychologists neglected emotions in their studies. However, emotions have once again become the focus of vigorous interest in philosophy as well as in other branches of cognitive science in recent years.

3.2.1 Non-Cognitive Approaches

Feeling Theories

William James proposed that emotions are specifically feelings caused by changes in physiological conditions relating to the autonomic and motor functions, where each emotion involves a unique bodily change. James maintained that we feel sorry because we cry, angry because we strike, afraid because we tremble and not the other way round [James, 1884]. Cannon [1929] criticized this theory stating that the visceral reactions characteristic of distinct emotions such as fear and anger are identical, and so these reactions cannot be what allow us to tell emotions apart.

LeDoux [1999] explained feelings using working memory by describing how the activity of a specialised emotion system is represented in the system that gives rise to consciousness, hence leading to feelings. He showed that a limited number of emotions do have significantly different bodily profiles. However, bodily changes and the feelings accompanying these changes are insufficient for establishment of an adequate taxonomy. Although some forms of general arousal can be easily labelled with certain emotional states, it is impossible to find a principle distinguishing factor between specific emotions in terms of physiological conditions. Due to lack of standard classification for specific emotions, we employ emerging emotions with no explicit labelling of states. In our view, the interpretation of emotions depends highly on the observer and is influenced by circumstances, experiences and norms.

Theorist	Fundamental emotions	Basis for selection	Reference
Arnold, M.B.	anger aversion courage dejection desire despair fear hate hope love sadness	relation to action tendencies	Arnold (1960)
Ekman, P.	anger disgust fear joy sadness surprise	universal facial expressions	Ekman, Friesen & Ellsworth (1982)
Frijda, N.	desire joy pride surprise distress anger aversion contempt fear shame	forms of action readiness	Frijda (1987, and personal communication)
Gray, J.	rage/terror anxiety joy	hardwired	Gray (1982)
James, W.	fear grief love rage	bodily involvement	James (1884)
McDougall, W.	anger disgust elation fear subjection tender-emotion wonder	relation to instincts	McDougall (1926)
Mowrer, O.H.	pain pleasure	unlearned emotional states	Mowrer (1960)
Oatley, K, and Johnston-Laird, P.N.	anger disgust fear happiness sadness	do not require propositional content	Oatley & Johnston-Laird (1987)
Panksepp, J.	expectancy fear rage panic	hardwired	Panksepp (1982)
Plutchik, R.	acceptance anger anticipation disgust joy fear sadness surprise	relation to adaptive biological processes	Plutchik (1980)
Tomkins, S.S.	anger interest contempt disgust distress fear joy shame surprise	density of neural ring	Tomkins (1984)
Watson, J.B.	fear love rage	hardwired	Watson (1930)
Weiner, B.	happiness sadness	attribution independent	Weiner & Graham (1984)

Table 3.1: A selection of lists of "fundamental" or "basic" emotions from Ortony et al. [1988]

For Antonio Damasio, the capacity for emotions involves 'somatic markers', an ability of the brain to monitor the body's past and hypothetical responses [Damasio, 1999]. Damasio [1994] proposes the existence of a body-mind loop in emotional situations in contrast to Descartes' proposal of the separation of mind and body. He provides neurological support for the idea that there is no 'pure reason' in the healthy human brain but emotions are vital for healthy rational human thinking and behaviour. Damasio defines the most universal emotions as Happiness, Sadness, Anger, Fear, Surprise and Disgust. Table 3.1 provides a list of primary emotions as defined by different emotion researchers. Although we agree with Damasio's body-mind concept of emotion, we do not adopt Damasio's view on 'primary' and 'secondary' emotions as this again involves explicit labelling of emotions.

3.2.2 Cognitive Approaches

An important feature neglected by the non-cognitive approaches is that emotions involve evaluations. The specific nature of the individual's emotion is a function of their appraisal of the situation as having some significance to themselves. Hence, appraisal theories can be described as a functional approach to emotion. For example, someone praises me and I feel happy; I only become happy through the interpretation that the person's remark is something positive about me.

Psychological Approaches

The concept of appraisal was introduced by Arnold [1960]. She characterizes appraisal as the process through which the significance of a situation for an individual is determined. Arnold defined emotions as 'felt action tendencies' that characterise experience and differentiate it from mere feelings of pleasantness or unpleasantness. Physiological changes follow this attraction or aversion leading to approach or withdrawal. Different patterns of physiological changes are what characterise different emotions.

Frijda [1986] departed from Arnold's account that appraisal gives rise solely to attraction and aversion. He defines emotions as changes in action readiness - changes in readiness for action, changes in cognitive readiness, changes in action tendencies or changes in readiness for specific concern-satisfying activities. To him, 'action tendencies' refer to states of readiness to modify or establish relationships with the environment. His theory maps the patterns of action readiness onto a set of output emotions. He claims that a machine with only limited power and knowledge, needs to be satisfied, and possibly encounter difficulties at every corner, would have to be emotional in order to survive. Frijda [1993a] suggested the existence of primary and secondary appraisals in the process of emotion elicitation in which events are continously monitored with respect to their concern relevance and coping possibilities. The emotional motivations will lead to emotional goals that transform desire or discomfort into the anticipated final states [Frijda, 2004].

Lazarus [2001] stresses that appraisals are both necessary and sufficient for emotion, initiated consciously or unconsciously. He takes the stand that coping is an integral part of the emotional process, serving as a bridge between the relational meaning of a transaction and how an individual acts and feels. He sees the identity of particular emotions as being completely determined by the patterns of appraisal giving rise to them. Therefore, when we make an irrational decision, it is reason that failed us, not our emotions. Whilst he believes that thought can occur without significant emotion but not vice versa, he rejects the notion that an ideal human is one who only thinks rather than feels.

Scherer [2001] proposes the idea that emotion differentiation can result from a sequence of 'stimulus evaluation checks'. This theoretical effort leads to the 'component process model of emotion' where emotion is treated as a psychological construct consisting of five components, each corresponding to a distinctive function: cognitive, peripheral efference, motivational, motor expression and subjective feeling. We adopt Scherer's view that emotion process is a continuously fluctuating pattern of change in these subsystems, yielding an extraordinarily large number of different emotions, but consider his compilation of appraisal patterns for modal emotions unnecessary.

Similar to Scherer, the OCC taxonomy [Ortony et al., 1988] attempts to address the issue of emotional differentiation, but instead of describing every possible emotion, it works at the level of emotional clusters, called emotion types, illustrated by Figure 3.13, where emotions within each cluster share similar causes. It also attempts to characterise individual emotions by specifying both the eliciting conditions and variables that influence the intensity of these distinct emotions. The authors view emotions as valenced reactions that result from three types of subjective appraisals: the appraisal of the desirability of events with respect to the agent's goal, the appraisal of the praiseworthiness of the actions of the agent or another agent with respect to a set of standards for behaviour and the appraisal of the appealingness of objects with respect to the attitudes of the agent. A compound set of emotions caused by combinations of other emotions is also proposed. Example implementations of this theory are discussed in Section 3.4.2.

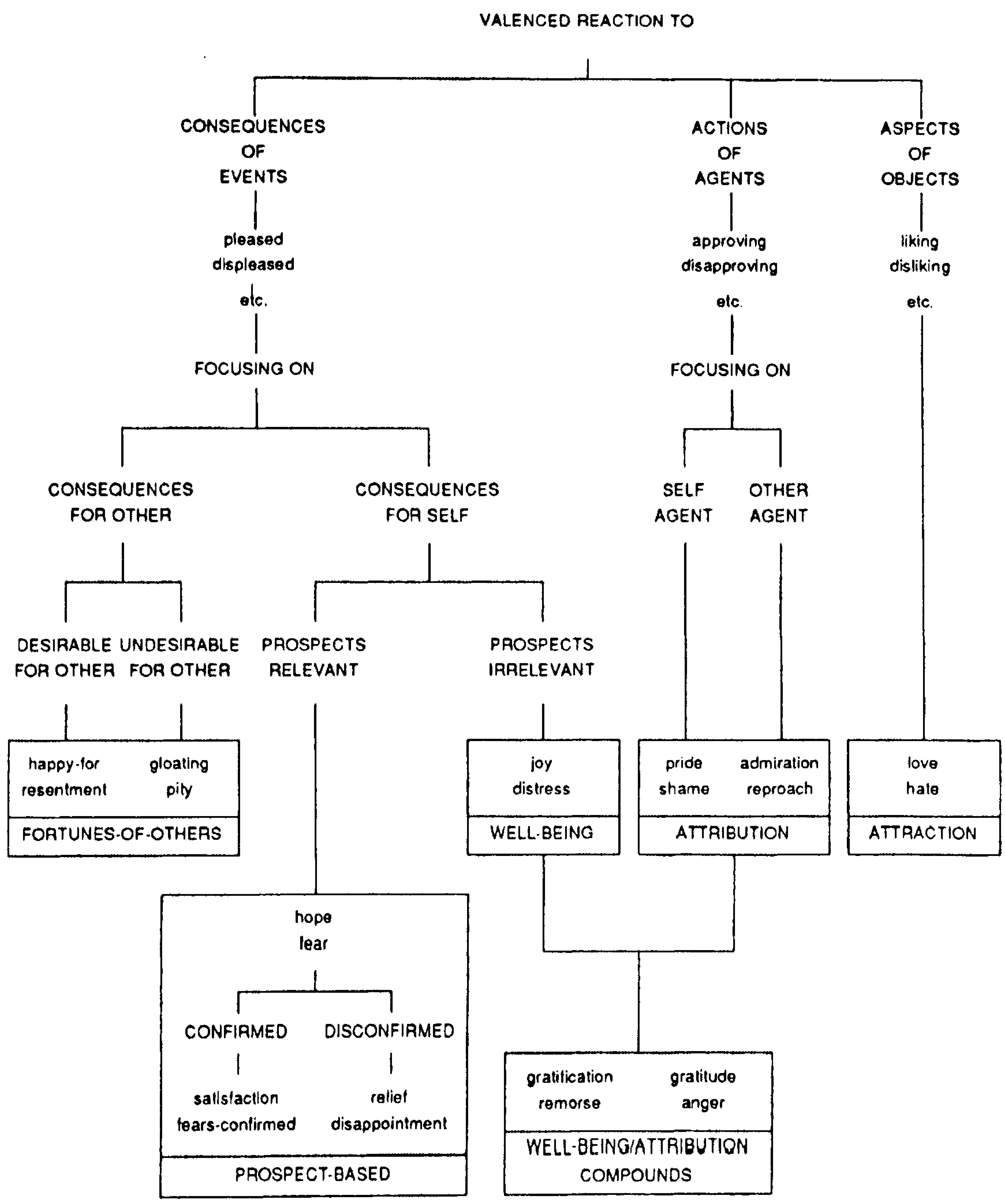


Figure 3.13: Global structure of emotion types (from Ortony et al. [1988])

Evolutionary Approaches

Darwin [1899], on the other hand, was concerned with the question of why emotions should have the forms of expression that they do. He found that emotion expressions serve particular functions and accompany particular emotions as a way of communicating these emotions to others. He focused his attention entirely on expressive behaviour such as facial expression, posture and gesture rather than subjective feelings, believing that emotional expressions have an evolutionary history.

For Plutchik [2003], emotions are an adaptation whose purpose is to solve basic ecological problems facing organisms. Plutchik suggested that one can account for any emotion by a mixture of the principal emotions and that emotions are rarely perceived in a pure state. He represented his theory of emotion mixes in a circle of emotions comprised of 8 basic emotions and by combining adjacent pairs, new emotions are created. He identified three characteristics of emotions: they vary in intensity, they vary in degree of similarity and they express bipolar feelings.

Paul Ekman, inspired by Darwin's approach, takes emotional expressions to be important parts of 'basic emotions'. Ekman suggested that the concept of basic emotions accounts for the similarity of basic emotional expressions across individuals and cultures, while display rules account for the differences [Ekman and Oster, 1979]. He suggested that the individual's ability to express and judge facial expressions varies, which further confirms the appropriateness of our approach putting the freedom of interpretation with the observer. Ekman reviewed work that investigated a feedback loop between emotions and the body. In one of the studies, subjects were asked to move certain facial muscles linked to the characteristics of different emotions without mentioning the emotion. They were then asked to answer some questions about their mood and the result showed that the subjects' mood was influenced by their facial expressions. So, when you are feeling blue, try putting on a smile!

3.2.3 Hybrid Approaches

As an alternative to emotion theories that focus either on the non-cognitive or the cognitive processes as the sole means of eliciting emotions, Izard [1993] divides

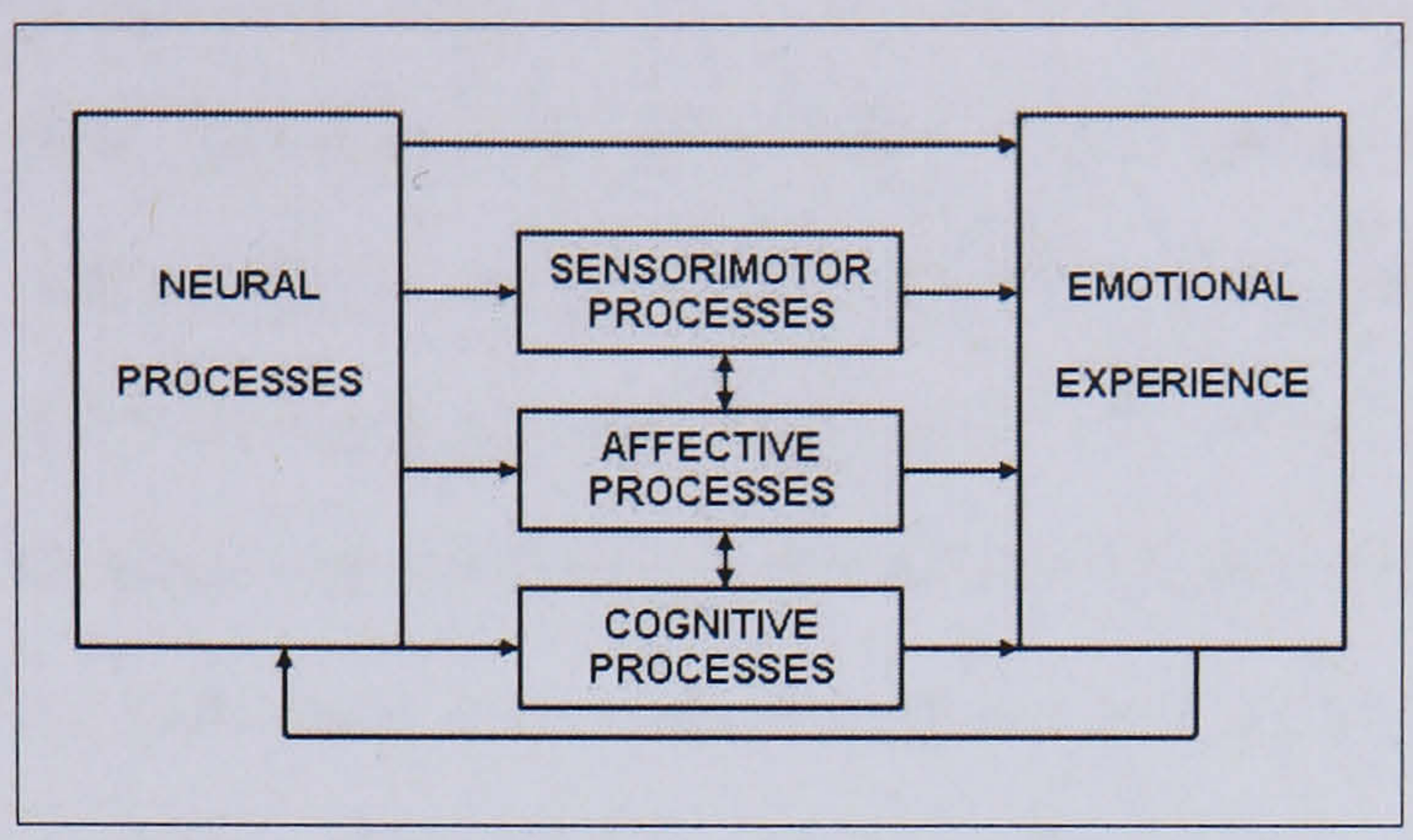


Figure 3.14: A multisystem model of emotion activation (from Izard [1993])

activators of emotion into four highly interactive and adaptive groups: Neural, Sensorimotor, Motivational and Cognitive as depicted in Figure 3.14. The system is a loosely organised hierarchical system of emotion activators influenced by individual differences, social variables and environmental conditions, with the neural system as primal and the cognitive system as the most complex. Emotion generation in each of the systems involve different elicitors as listed below:

- Neural system: Activity of neurotransmitters and brain structures that are influenced by hormones, diet, sleep, electrical stimulation, etc.
- Sensorimotor system: Efferent or motor activities such as facial expression, body posture; may include afferent feedback from muscle activity, muscle spindles or cutaneous receptors
- Motivational system: Physiological drives and emotions
- Cognitive system: Cortical processes

Opposing appraisal theories, Izard provided evidence that using cognitive processes alone to explain emotion activation is incomplete. He took cognitive processes as one of several factors that influence emotion generation rather than as a necessary or sufficient factor. On the other hand, the neural systems are capable of independent processing. This model implies a continuous feedback loop between the motivational systems and the cognitive systems, where ongoing emotion combined with foregoing cognitive processes leads to a new emotion resulting in further cognitive processes, and so on. This idea reflects our view on emotion.

Affirming this view, psychologist Dietrich Dörner proposed the 'Psi' theory [Dörner and Hille, 1995, Bartl and Dörner, 1998], integrating cognition, emotion and motivation for human action regulation. The 'Psi' theory is based on the argument that humans are motivated emotional-cognitive beings. Motivation represents needs that influence survival; emotions are modulations of cognitive processes; whilst cognition refers to those processes that control adaptive behaviours, including perception, action-selection, planning and memory access. Needs can be existential (eg. need for water and affiliation) or intellectual (eg. need for competence and certainty). The modulating parameters of cognitive processes that are affected by emotions are defined as:

- Arousal: Speed of information processing
- Selection threshold: Tendency to concentrate on a particular intention
- Resolution level: Carefulness or attentiveness of behaviour
- Background checks: The frequency of screening the background

These parameters have also been identified by Hille [2007] as aspects of behaviour that define emotions. Hille added a fifth parameter, the level of goal-directed operation, which she defined as the proportion of operation to non-operation for the realisation of a goal. The 'Psi' theory is unique in that emotions are not explicitly defined but emerge from modulation of information processing and action selection. Complex behaviours become apparent when the modulating parameters values are modified by needs resulting in what can be termed as emotions. The interaction between motivation, emotion and cognition is a continuous loop within the organism, regulated by both internal and external circumstances.

Figure 3.15 shows the internal structure of the 'Psi' agent. Whenever a need deviates from the set point, it activates the corresponding motives. Several motives may be active at a particular time and one of these motives is selected according to an expectancy-value principle. The selected motive is the actual intention that is executed. There are three different modes of execution: automatism, knowledge-based or trial-and-error. If the 'Psi' agent is highly experienced in performing the current intention, a complete course of action to achieve the goal is carried out automatically, otherwise it generates a plan to achieve the goal. If both these fail, it explores the environment to collect information that will lead to the goal.

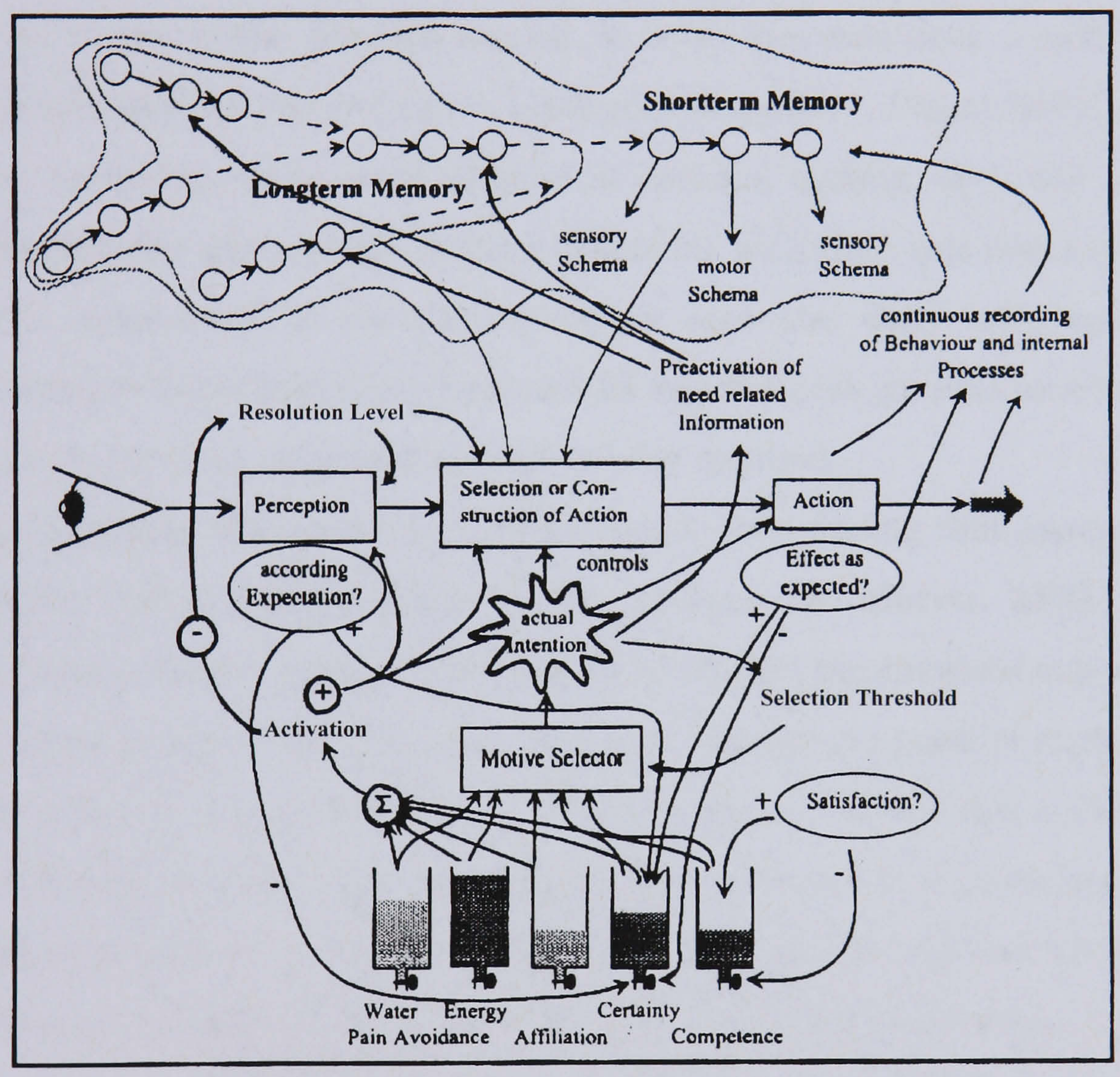


Figure 3.15: The internal structure of 'Psi' (from Bartl and Dörner [1998])

The 'Psi' agent learns by experience and possesses a memory system in which all perceptions and activities are continously recorded. This memory may be exposed to decay as well as amplification. The memory traces of the immediate past and those that are concerned with needs satisfaction are very dense and less susceptible to decay. With continuous activation, this memory may eventually become long-term memory, whereas other weaker memory chains will be destroyed rather quickly. Hence, the agent reacts to the environment by forming memories, expectations and immediate evaluations. Moreover, by varying the weight of these parameters, agents with different personalities can be defined. This model has been successfully implemented and will be discussed in Section 3.4.3.

3.3 Emotional Memory

From the review in the previous section, it is obvious that both cognition and emotion are essential parts of future intelligent computers. Picard [1997] argued that for computers to be truly effective at decision making, they will have to have emotion-like mechanisms working in concert with their rule-based systems. Moreover, since much of the information we encounter daily holds emotional significance, we argue that it is not enough for an intelligent guide to have memory about facts, but that emotional memory is also required.

This argument is supported by recent neurological finding that memory files contain not only data or information but emotions too [Carver, 2005]. Thus, memory files consist of information about an event and the emotions experienced at the time the event occurred. This confirms LeDoux's proposal of explicit and implicit memory. According to LeDoux [1999], our brain contains a variety of different memory systems that work in parallel to give rise to independent memory functions. Conscious, declarative or explicit memory is mediated by the hippocampus and related cortical areas, whereas implicit emotional memory involves the amygdala and related areas as illustrated in Figure 3.16. The hippocampal system lets us remember the details of a situation, whilst the amygdala system produces stimuli that activate our body chemistry for the emotional situation.

It is the emotional arousal, not the importance of the information that organises memory [ICRA, 2005]. The stronger the emotional factor, the longer the memory remains due to the fact that emotional arousal has a key role in the enhancement of memories for significant information [Gold, 1992]. As a result, emotional events occupy a large portion of our long-term memory relative to neutral or everyday events. However, the correlation between emotional arousal intensity and memory strength is not necessarily linear [Richter-Levin and Akirav, 2003]. Emotional arousal can sometimes impair memory as in the case of trauma but this issue is out of the scope of this discussion.

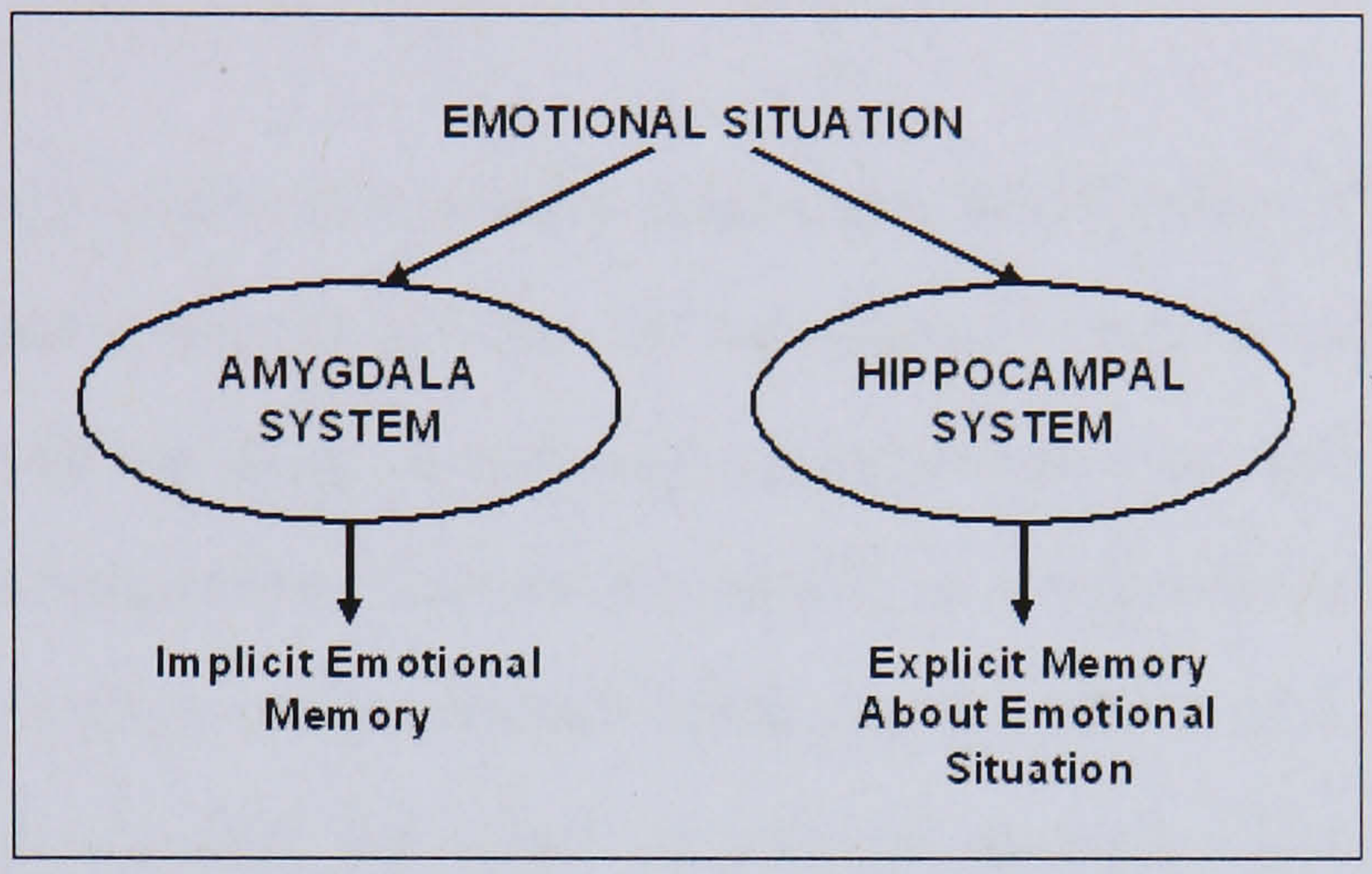


Figure 3.16: Brain Systems of Emotional Memory and Memory of Emotion (from LeDoux [1999])

It has also long been known that emotionally arousing events are more likely to be later recollected than similar, neutral events [Riesberg and Heuer, 1992]. When we retrieve an emotional memory file, we relive the old events [Carver, 2005]. Those memories are part of what makes up our personality, controls our behaviours and often produces our mood. According to Carver, our mood starts to change 90 to 120 seconds after an emotional memory file is accessed. So, a depressing emotion may be prevented from coming to the surface by switching attention to other memory files with positive emotions. Therefore, similarly to emotion, emotional memory has coping and adaptive qualities to help in dealing with future circumstances.

In emotionally arousing events, the amygdala is activated to mark the experience as important and aid in enhancing synaptic plasticity in other brain regions, a concept called *Emotional Tagging* [Richter-Levin and Akirav, 2003]. The activation of the amygdala during an emotional event has also been noted by LeDoux who further stressed the essential role of the amygdala in the formation of emotion-related memories. This process facilitates the transformation of early-phase memory into long-term memory. While the amygdala plays an important role in modulating memory consolidation [McGaugh et al., 1996, Hamann, 2001], [Dolan et al., 2000] identified two distinct regions of brain activity specifically related to emotional memory retrieval - the anterior temporal cortex and the left amygdala.

A different study was performed by Kensinger and Corkin [2004], who held the idea that emotional information can be categorised into two dimensions: firstly arousal, that is, how exciting or calming an experience is; and secondly valence, that is, whether an experience causes a positive or a negative impact. In addition to previous studies that concentrated solely on the effect of arousal on memory enhancement, they studied the effect of valence as well. They investigated the consequences of cognitive and neural processes on enhancement for arousing versus valenced but non-arousing information. Consistent with previous findings, their neuroimaging data reflects that an amygdalar-hippocampal network is involved in enhancement of emotional arousing information. On the other hand, the prefrontal-cortex-hippocampal network was found to play a role in enhancement of valence information.

Whilst these studies are relevant to our investigation, we are not modelling the brain functions. The main point is that it is the associated emotion that brings an experience to life. This implies that our autobiographic memories [Dautenhahn, 1998b], allowing rich recollective experiences, are made up of emotional memories. Hence, in order to tell believable life stories, we stress the requirement for emotional memory in the Affective Guide.

3.4 Emotion-based Architectures

Researchers on character development have examined the design of motivational structures, emotional and personality traits and behavioural control systems for characters that perform in context-specific environments with well-defined goals and social tasks [Doyle and Isbister, 1999, Johnson et al., 2000]. They have long wished to build characters with whom a user might want to share some of their life, whether as a companion or a social pet. In the following section, some implemented architectures based on emotion theories will be discussed. New models are still being developed, therefore to explore all of them would be tedious, if not impossible. Hence, only architectures that are relevant to this research are reviewed. Some of these architectures include emotional memory in the implementation.

3.4.1 Non-cognitive Architectures

Cañamero

Cañamero [1997] proposed a non-symbolic architecture that relies on both motivations and emotions to perform behaviour selection for an autonomous creature. In her system, motivations are homeostatic processes, involving arousal and satiation, whilst emotions are modifiers of bodily and motivational states. Motivations direct, activate and organise behaviour while emotions influence perception and attention. Emotions constitute a 'second order' control mechanism running in parallel with the motivational control system to continuously monitor the external and internal environment. The system includes explicit mechanisms for a subset of discrete emotions and allows activation of several emotions simultaneously.

Cañamero used a two-dimensional grid, inhabited by geometrical figures, as the simulation world. The Gridland is populated by living beings - Abbotts and Enemies, food and water sources, and inanimate blocks of varying shapes. In order to survive in this dynamic environment, the creatures need to make rapid choices to satisfy their needs. Each creature has a set of physical attributes, a set of physiological variables and a collection of 'agents' (functional units) that sense, perceive and act. The physiological variables consist of "controlled variables" and "hormones". External events and changes to physiological variables activate emotional states which modify intensity of motivations depending on the release of hormones that further influence the action selection mechanism. In other words, emotion alters motivational priorities and behaviour execution through the effect of released hormones on the physiology, arousal, attention and perception of the creatures.

Velásquez

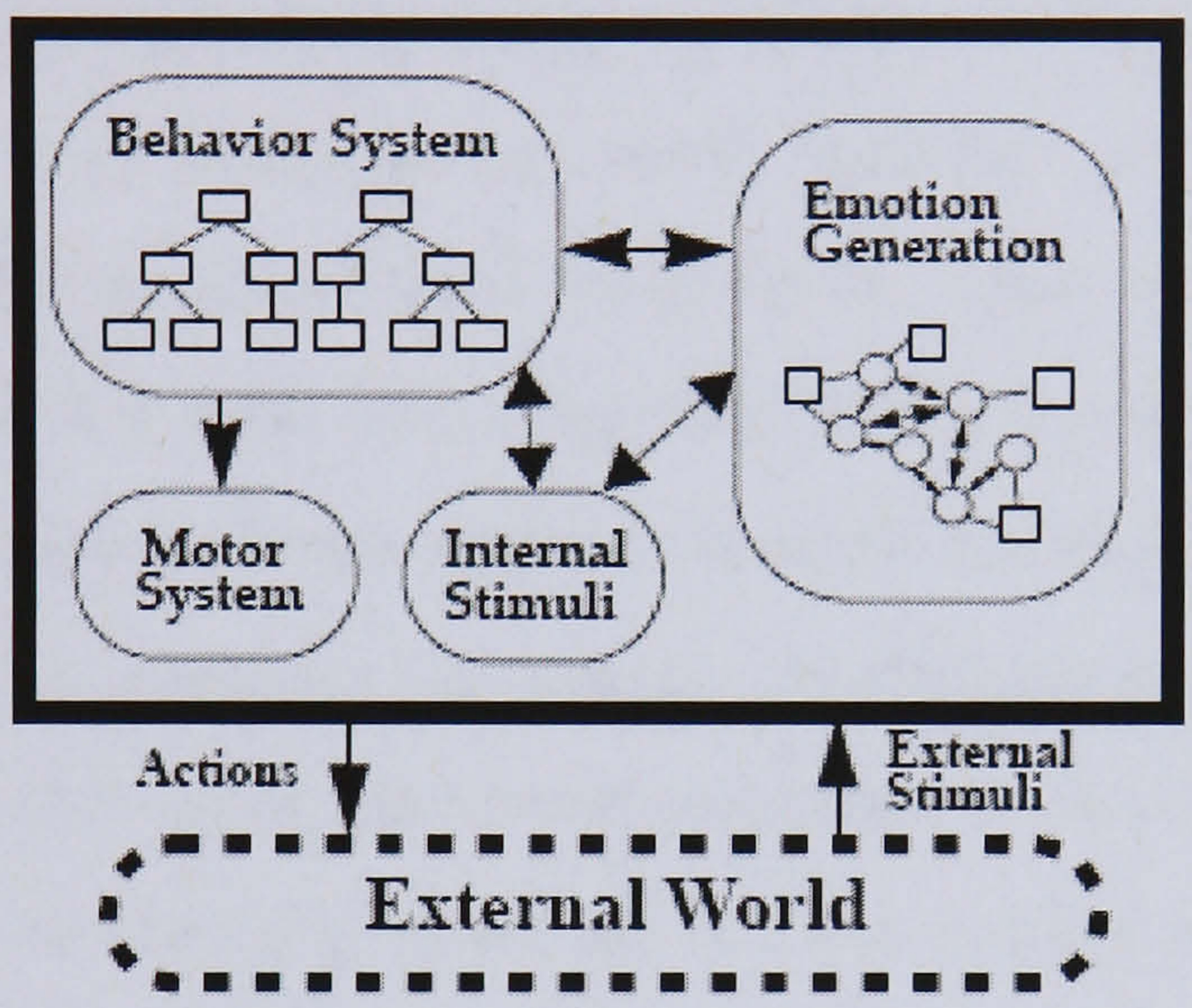


Figure 3.17: The Cathexis Architecture (from Velásquez [1997])

Velásquez [1997] developed Cathexis, a comprehensive architecture of emotion based on Izard's four systems model [Izard, 1993], integrating both cognitive and non-cognitive emotion elicitors, shown in Figure 3.17. However, Velásquez is more concerned with the neural mechanism underlying emotional processing than cognitive evaluation of emotional experiences. His work focuses on generating emotions for behaviour control. Similar to Cañamero's approach, the so-called basic emotions are explicitly modelled and activation of more than one emotion at a particular time produces mixed emotions. At any point in time, given the emotional state, the Behaviour System selects an appropriate behaviour for the agent to display.

A later version of Cathexis shows how the basic emotions can be used as building blocks for the acquisition of emotional memories serving as biasing signals during decision making and action-selection processes [Velásquez, 1998]. Instead of pre-wiring the cognitive elicitors, the new version allows these elicitors to be learned through the agent's interaction with the world. The Behaviour System was also refined by allowing non-conflicting actions to occur simultaneously. This framework provides control for an emotional pet robot, *Yuppy*. *Yuppy's* emotional memories [LeDoux, 1999] were modelled with an associative network, formed when previous emotional experiences were fed back to the Behaviour System. These memories influence its future decisions and behaviours.

Both Cañamero and Velásquez proposed emotion architectures for action-selection from a physiological-oriented perspective. These architectures are useful for developing agents that have only existential needs but are insufficient for controlling the Affective Guide where intellectual needs are more important. Furthermore, these approaches associate antecedent events with specific emotions. As a result, the agents do not show emotional responses to novel situations, whereas we opt for a flexible mechanism which should not require explicit pre-definition of emotion activation conditions.

Blumberg

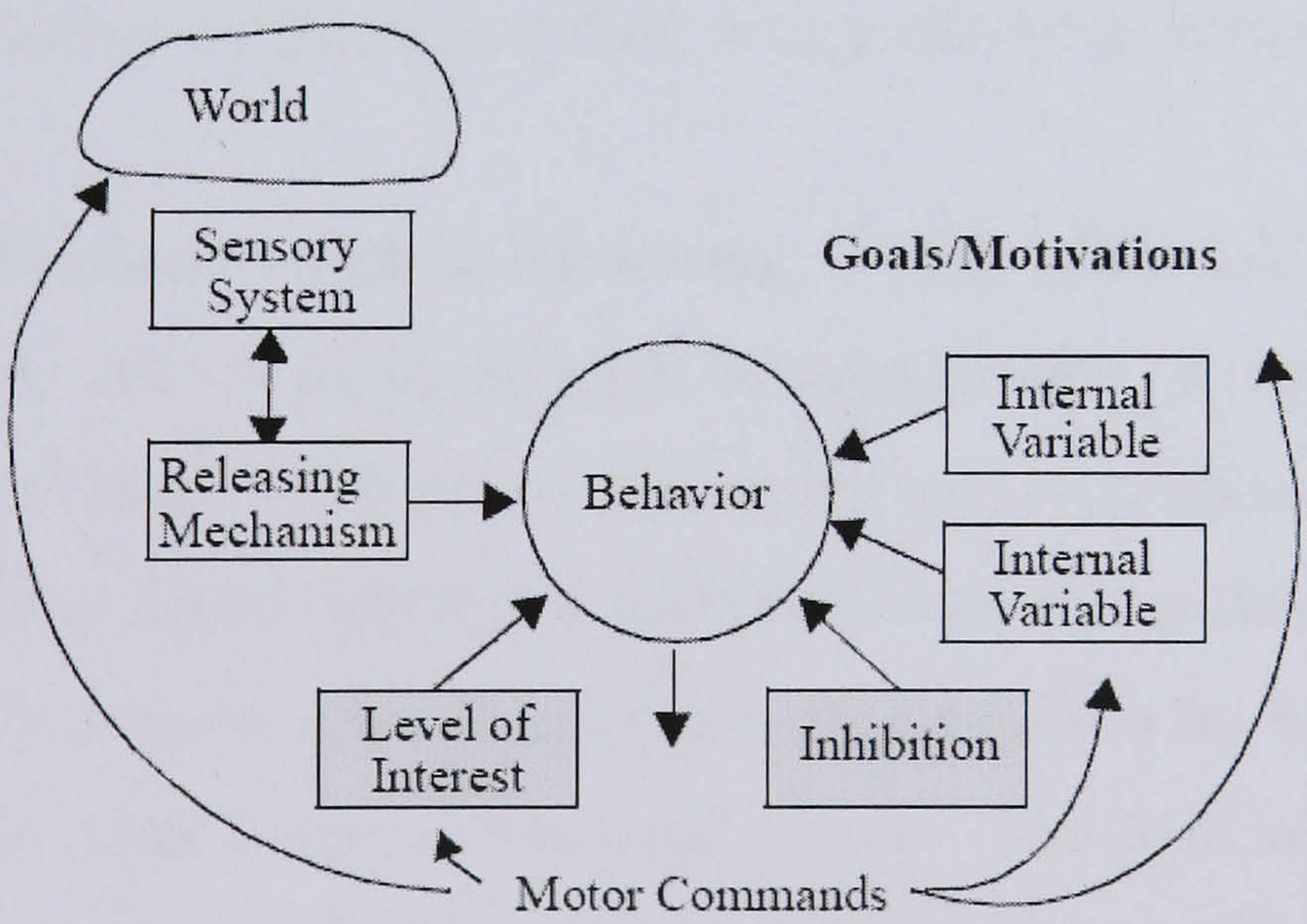


Figure 3.18: Silas's Behaviour System (from Blumberg [1996])

A simple mechanism of action-selection and learning was proposed by Blumberg [1996] combining the perspective of ethology and classical animation. He addressed the problems for building autonomous creatures, involving the creatures' behavioural coherence, behavioural relevance, learning, intentionality expressions and means for external control. Blumberg developed an animated dog, Silas, modelled closely after ethological models of animal behaviour. Silas possesses simple *internal variables* that represent motivations and emotions influencing what it learns. Silas tries to determine stimuli from his perception and have a set of *releasing mechanisms* that filter significant sensory input. Both the *internal variables* and the *releasing mechanisms* determine the appropriateness of behaviour at any given instant as shown in Figure 3.18. *Level of interest* models behaviour-specific fatigue, while *Inhibition* allows competition among behaviours based on the winner-takes-all approach.

A more recent implementation of the model is *AlphaWolf* [Tomlinson and Blumberg, 2002], capturing a subset of the social behaviour of wild wolves. The emotion model is based on the Pleasure-Arousal-Dominance model presented by Merahbian and Russell [1974]. The wolves are able to form social relationships with other wolves and when they interact, they re-experience the emotions that they experienced during previous interactions. The wolves' emotions lead to the formation of context-specific emotional memories based on the 'somatic marker hypothesis' presented by Damasio [1999], which affects how they will interact in the future.

Although Blumberg's work is interesting, it was developed with only young animals in mind. The level to which it is implemented is again too low level for the Affective Guide which requires planning and storytelling capabilities. It focuses on building highly expressive animated creatures rather than emotional agents, that is, it concentrates on geometry manipulation for behaviour expressions, not on creating internal emotional states. The idea of re-experiencing emotions through activation of emotional memories is relevant to our research but we are not interested in providing the Affective Guide with a developmental learning capability.

3.4.2 Cognitive Architectures

ACRES

ACRES [Moffat et al., 1993] is an emotional database-interface that was based on Frijda's theory of emotion [Frijda, 1986]. ACRES has several concerns ranked in decreasing order of importance: to stay alive, to prompt the User for input, to have accurate input, to have varied input, to do what the User wants and to turn tracing/debugging on and off. It allows the user to request data, turn debugging on and off, request its last experienced emotion, and to end the interaction session. ACRES outputs either the expected response to a query or a spontaneously generated "emotional expression". It has an internal monitor to analyse and name its emotional experience consistent with its behaviour. The emotional expressions are to indicate the system's emotional state to the Users, hence change their behaviour to comply with the system's wishes. Users that do not follow its wishes will be gradually excluded from the system, losing their privileges. Hence, ACRES has some control over its environment.

Although ACRES demonstrated emotional behaviour that seems plausible to the User, it can sometimes be unstable. It can be 'happy' one minute and 'angry' the next, or even produce conflicting emotional responses concurrently. This is because ACRES does not have autonomic arousal or other physiology regulation as in humans, and has virtually no memory. It has a rigid emotional response mechanism that generates the same expression everytime the same situation occurs, hence lacking flexibility and variation in its reaction.

The OCC Architectures

The OCC model described in Section 3.2.2 is one of the most used appraisal models in current emotion synthesis systems. It remains a key reference for the development of applications, in particular in the domain of embodied conversational characters. Numerous implementations exist, beginning with the Affective Reasoner architecture [Elliot, 1992] then the Em component [Reilly and Bates, 1992] of the Hap architecture [Loyall and Bates, 1991], EMA [Gratch and Marsella, 2004] and many more.

Hap keeps a goal tree of current active goals, and when it discovers a goal success/failure it alerts Em. Because Em cannot directly assess the cause of a goal's success/failure, Em judges (un)desirability based on the outcomes of the agent's goal. Em judges its (dis)approval of actions based on two standards: help-my-goals-to-succeed and do-not-cause-my-goals-to-fail. Objects are (dis)liked by matching them against a pre-defined object-attitude list. Emotions that influence the agent's behaviour are created simply by searching and combining all currently active emotions. The Em component implements only a subset of the OCC model, and does not differentiate between emotions of the same type. Besides generating emotions, Em keeps track of thresholds for every emotion type, manages emotion decay and manages interpersonal relationships between agents.

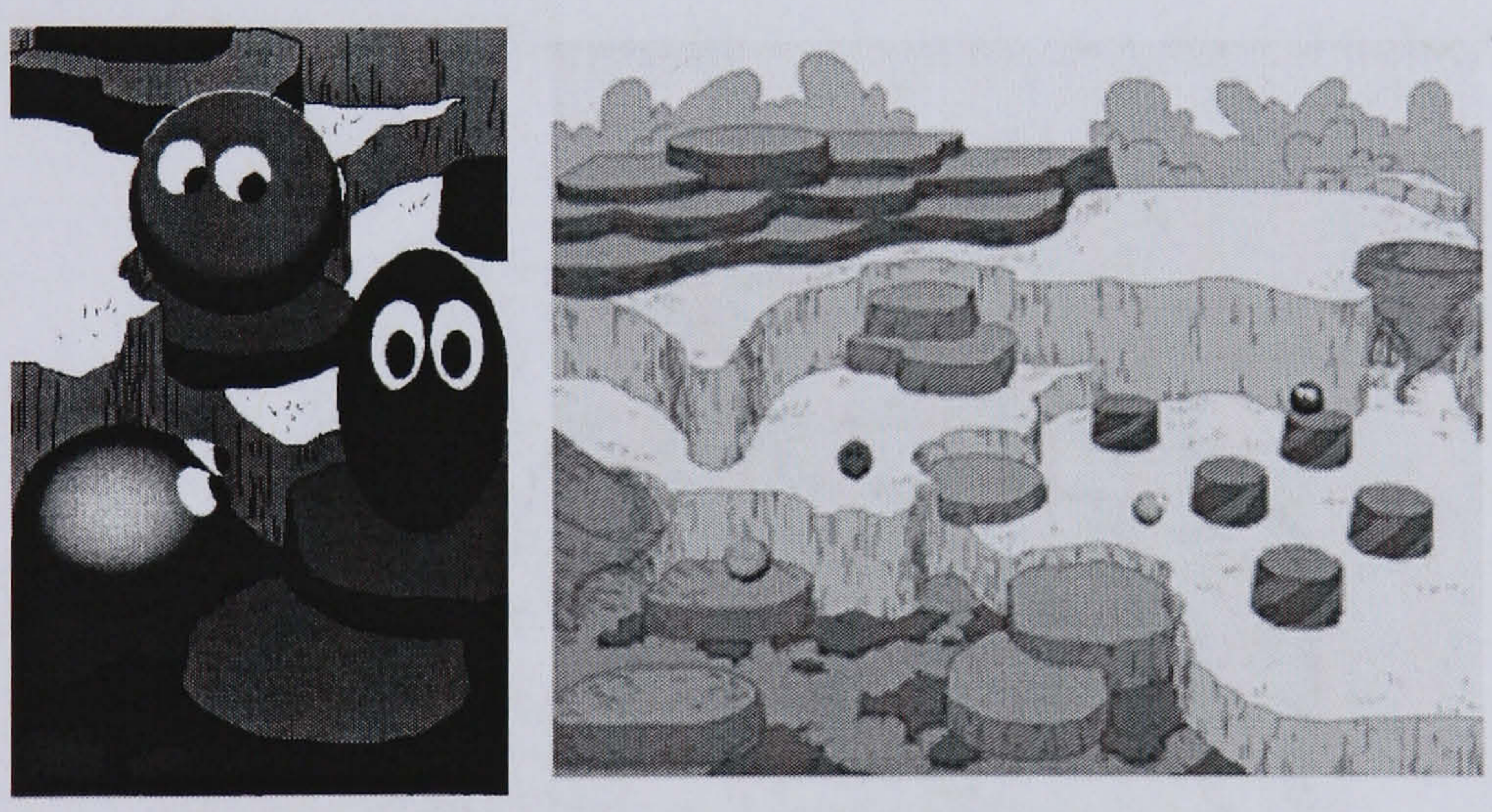


Figure 3.19: Woogles and their simulated world (from Bates [1994])

Hap is utilised in the Tok architecture of the Oz project [Bates et al., 1992, Bates, 1994], aimed at producing agents with a broad set of capabilities, including goal-directed and reactive behaviour, emotional state, social knowledge and some natural language abilities. A Tok agent occupies a physically simulated world as illustrated in Figure 3.19, continuously performs a sense-think-act cycle and has goals, standards and attitudes. Individual *Woggles* had specific habits and interests which were shown as different personalities. Social relations between the agents directly influenced their emotional systems and vice versa. However, Oz focused on building shallow, specific, unique believable characters, where the goal was an artistic abstraction of reality, not biologically plausible behaviour.

3.4.3 Hybrid Architectures

Aaron Sloman

Sloman [2001] presented a much more complex human-like architecture, blurring the division between cognition and emotions in a three-layered framework as illustrated in Figure 3.20. An almost similar three-layered architecture can also be found in [Ferguson, 1992]. Sloman viewed emotions as embedded in the complete agent model and classified them into primary, secondary and tertiary resulting from processes in each of the three layers of his framework respectively. The reactive layer, deliberative layer and meta-management layer operate concurrently with increasing complexities and capabilities from one layer to the next.

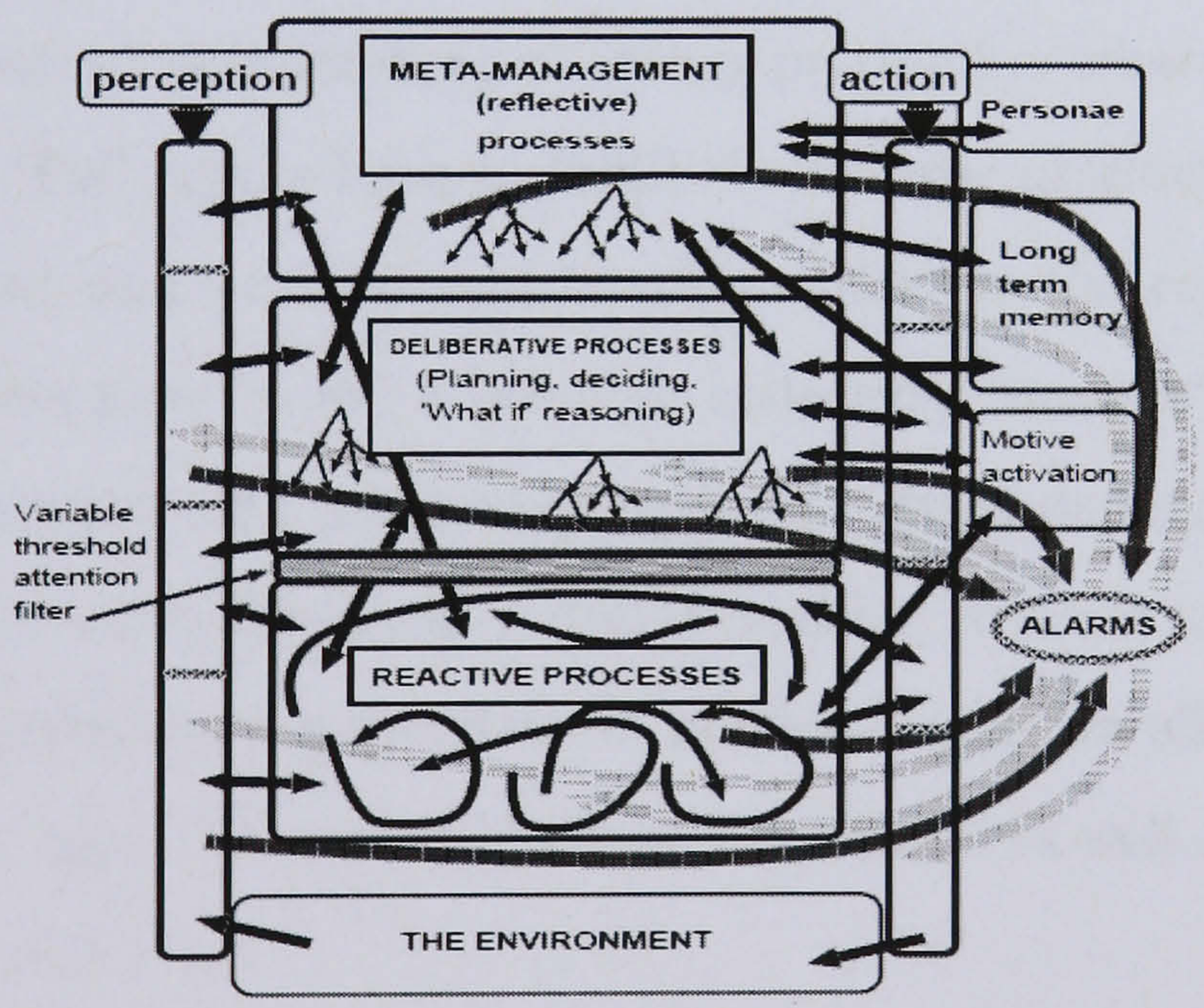


Figure 3.20: The H-cogAff Schema (from Sloman [2001])

Reactive systems sense internal or external conditions and produce state changes. Information processing in this layer is usually a fixed collection of condition-action associations, hence it lacks the ability to represent, evaluate and compare possible actions or consequences of actions. The deliberative layer is capable of addressing 'what if' scenarios and performing planning. There is interaction with emotional processes to generate affective states not achievable in a purely reactive architecture. A reactive organism may response with fear to a presently perceived threat, whereas a deliberative mechanism permits anticipation of possible consequences of actions in such situation. Finally, the meta-management layer permits self-reflection, allows for learning and controls future processes. One or more alarm systems detect patterns requiring rapid global behavioural responses. Hence, it is possible for processes in other layers to disrupt this layer and to override some of its decisions, leading to yet more complex states and processes.

The 'Psi' Architectures

Three successes of the 'Psi' model (see Section 3.2.3) in replicating human behaviour in complex task can be found in Bartl and Dörner [1998], Dörner [2003] and Dörner et al. [2006]. Bartl and Dörner [1998] used a scenario of a BioLab environment, a biological laboratory of energy production where both the human subjects and the 'Psi' agents have to fulfill three aims: production of electricity, production of heat and avoidance of contamination to the reactor. In Dörner [2003], the subjects have to aid a robot in collecting "nucleos" on an island by supplying it with water and fuel and preserving it from damage. Lastly, Dörner et al. [2006] detected behavioural patterns similar to overcrowding in human populations by modelling a population of artificial mice. In all these implementations, each 'Psi' agent has a set of built-in motivators as well as the modulators mentioned in Section 3.2.3.

Taking the artificial mouse, for example, it has six 'tanks' that represent its motivators including hunger, thirst, pain, affiliation, certainty and competence. If a setpoint deviation occurs in one of the tanks, the mouse will try to reduce it. Several tanks may show a set-point deviation at the same time, and the mouse will select the one of these motives with the highest success value. It then looks in its memory for a plan to satisfy this motive. If this fails, it will try to construct a new plan or adopt the trial-and-error approach. The motivator values trigger action tendencies and modulators. The arousal level then modifies both the resolution level and selection threshold values. This in turn determines the form of information processing, thinking, perceiving and other cognitive processes in the mouse. For example, if the environment poses threats, the arousal level rises, leading to a low resolution level and high selection threshold. In this case, short reaction times will be observed, with only superficial perception and planning taking place. The mouse will be highly cautious, exposing defensive behaviour. By doing so, it adapts its responses to the environmental conditions.

Since we aim to develop a biologically plausible agent, it seems appropriate to anchor our architecture in this direction, so that a more natural agent with behaviour compatible with humans can be produced. However, we model only the higher level needs, that is, the intellectual needs, as described in Chapter 6.

Others

A very similar approach to the 'Psi' model is that of Randolph M. Jones [2002], who investigated improved realism in generating complex human-like behaviour by integrating behaviour moderators (sub-symbolic components) with higher cognitive processes (symbolic components). The emotional attributes of the sub-symbolic component are an arousal system, a pleasure/pain system and a clarity/confusion mechanism. The symbolic component consists of an appraisal system and a response system. The appraisal system provides information to the behavioural model while the response system accepts information from it. Emotional states can be viewed as arising from a combination of pleasure/pain, arousal, clarity/confusion components. Variation along the emotional dimensions produces different personality agents.

In the model proposed by Oliveira and Sarmento [2003], emotion elicitation involves evaluating the chances of achieving a given goal regardless of the nature of the eliciting process, taking into account both the state of the environment, the internal state and the agent's coping capabilities. The resulting emotional mechanisms play an important role in providing and managing information as well as influencing operating modes and processing strategies. Emotions provide concrete information enabling quick reactions in complex environments, whilst information is managed through a selective process comparable to the *Emotional Tagging* concept discussed in Section 6.1.5. This process allows the most relevant facts to be selected and stored in the agent's memory. The authors also stressed the importance of mood-congruent memory in discovering opportunities and identifying possible threats based on past experiences. Mood-congruent memory is an interesting feature but we will not employ it in the current version of the Affective Guide.

Adjustment of plan granularity, execution time, action set and/or choice of heuristic employed determines the agent's operating mode. The possible processing strategies are direct access, motivated processing, heuristic processing and substantive processing. This model has been implemented in a forest fire environment simulator, the *Pyrosim* where the agents possess four emotional structures: fear, anxiety, self-confidence and frustration. The main drawback of this model is rigidity because each emotion requires definition of a structure. Emphasis appears to be placed on the influence of emotions on decision making rather than on the variability of the emotional model.

3.5 Facial Expressions

Having internal states, the guide needs a more obvious mechanism for expression in addition to its behaviour modulation. The most common means of expressing emotions is through facial expressions. There are many aspects of internal states which we can deduce from facial expressions, including physiological states, mental activities, social cues and emotions, the latter being the most obvious.

Why are the lip corners raised in happiness and drawn down in sadness rather than vice versa? Why are the eyebrows raised when we are surprised and not when we are worried? According to Darwin [1899], these expressions are innate, prewired, specialised signals and this argument has been supported by the discovery of universal facial expressions [Ekman and Oster, 1979]. In Darwin's account, the eyebrows of a person suffering from deep dejection or anxiety assume an oblique position due to the contraction of the frontal muscle that raises the inner ends of the eyebrows and the corrugators that draw the eyebrows together causing a lump to be formed. As a result, transverse wrinkles are observed across the forehead. At the same time, the outer portions of both eyebrows are drawn downwards and smoothed by the contraction of the orbicular muscle.

A universally recognised signal of being out of spirits is the depression of the corner of the mouth. In this situation, the fibres of the depressores anguili oris muscle contract to draw the corner of the mouth downwards and outwards, causing the lips to protrude, especially the lower one when the mouth is closed. This contraction may include the outer part of the upper lip and even to a slight degree the wings of the nostrils. Plutchik [2003] added that an opened and turned down mouth corner also occurs when a person is hurt, accompanied by pressed eyelids and tears being shed. On occasion, the eyebrows are so raised that frown lines appear between the eyes.

Conversely, happiness, joy and pleasure are expressed with laughter and smiling, during which the upper lip is somewhat raised with the corners drawn a little backwards and a little upwards. Darwin pointed out that Duchenne [1862] repeatedly insisted that the great zygomatic muscles acted on the mouth to draw its corners backwards as well as upwards under the emotion of joy. Concurrently, the lower orbicular muscles of the eyes are more or less contracted, raising the cheeks, causing wrinkles to be formed under the eyes. The nose may also appear shortened, the skin on the bridge wrinkled and a well-marked naso-labial fold formed beside the wing of each nostril down to the corner of the mouth. The contraction of the orbicular muscles and the pressure from the raised cheeks leads to bright and sparkling eyes.

When attention is required, the eyebrows raise slightly. The extent of this rise increases when the state turns into surprise. The raising of the eyebrows enables quickly and widely opened eyes due to a rise in arousal following emotions that accelerate the heart. This movement produces transverse wrinkles across the forehead. Surprise with pleasure can be perceived if the eyes brighten instead of remaining blank, followed by a smile. On the other hand, a further arousal coming after astonishment may result in fear, where the skin becomes pale. Contraction of the platysma myoides muscle amplifies the expression of fear, drawing the lower parts of the cheeks and corner of the mouth downwards and backwards as shown in Figure 3.21.

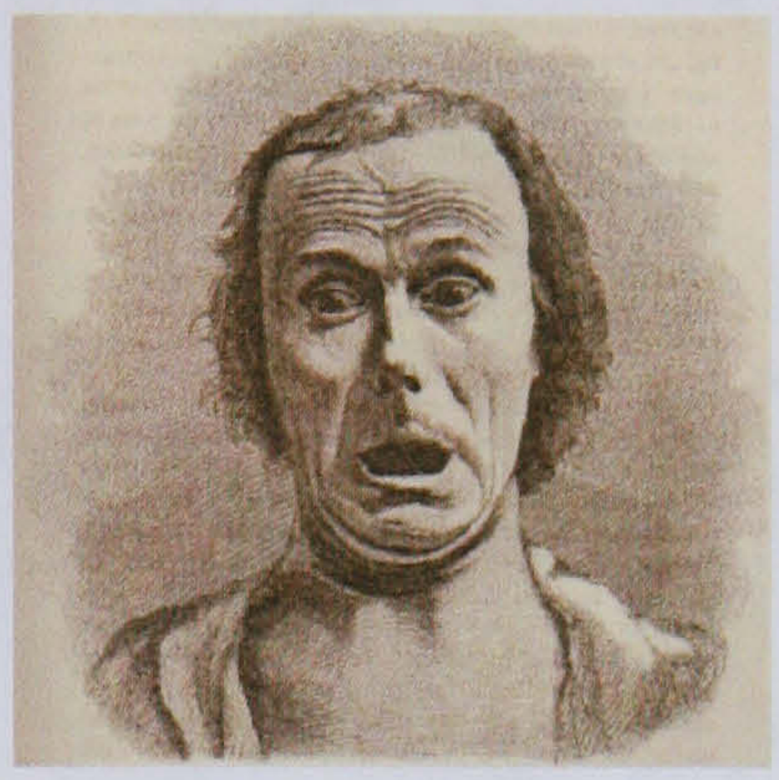


Figure 3.21: Terror - The eyes stare, the nostrils and pupils are dilated, the strong contraction of the *platysma* wrinkles the neck and helps to depress the lower jaw and keep the mouth open. The brow is horizontally furrowed and the general attitude is one of flaccidity and weakness (from Darwin [1899])

Facial expressions can be studied either by by direct measurement of facial activity or through an observer's judgments [Ekman and Oster, 1979]. One of the most well-known measurement system is the Facial Action Coding System (FACS) [Ekman and Friesen, 1982]. FACS was developed to provide a comprehensive scheme for distinguishing visual facial movements. FACS' chief use is for scoring facial actions seen on motion records and still photographs. It is based on visible muscle actions on the face, not including those that are too subtle for reliable distinction by human and invisible changes.

According to Ekman, if observers could tell what was happening, or if measurements of the face showed systematic variations with changing eliciting circumstances, then accuracy is established. Ekman's facial measurements are called *Action Units* (AUs) and there are 46 altogether, where each can involve more than one muscle change. Figure 3.22 shows an example of three AUs and the combination of these AUs to create different expressions. Each AU is described by providing the muscular basis in words and diagrams, detailed description of appearance changes, instructions on how to reproduce the AU, and a rule that specifies the minimal changes for its observation.

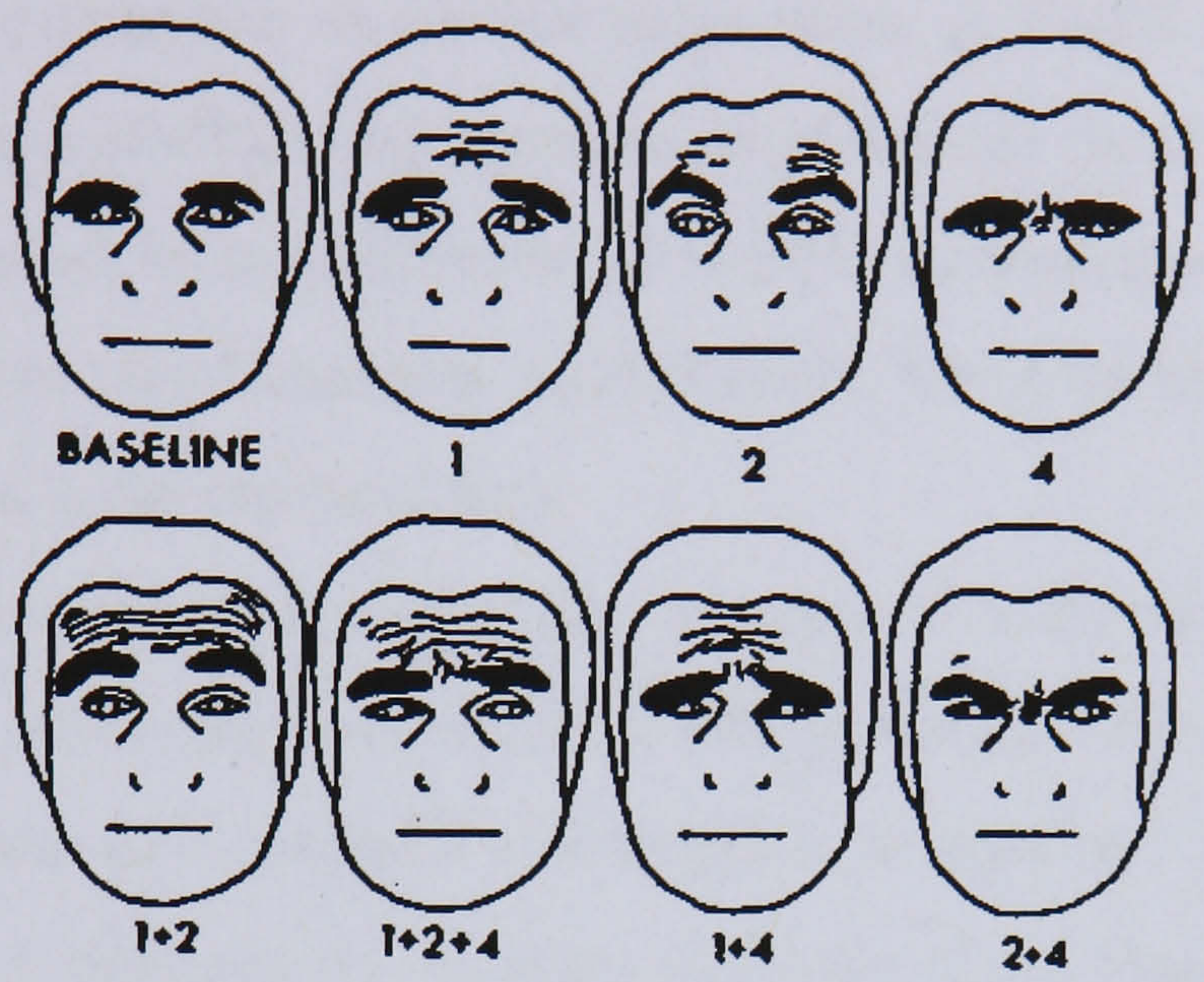


Figure 3.22: The three FACS action units in the brow area and their combinations. AU 1 (action of inner frontalis) raises the inner corners of the eyebrows, AU 2 (action of the outer frontalis) raises the outer portion of the eyebrows and AU 4 (action of procerus, corrugators, and depressor supercilii) pulls the eyebrows down and together (from Hager and Ekman [1983])

FACS allows the measuring of facial asymmetries usually observed during deliberate rather than spontaneous expression [Hager and Ekman, 1983] and provides a complete scoring for visible and reliably distinguishable actions of the brows, forehead and eyelids, but not the lower part of the face. It measures any facial movement, not only movements that may be relevant to emotion. Although FACS can be used to discriminate positive from negative emotional expressions, and the intensity of these expressions to some extent, some questions remain unanswered as posed by the authors themselves:

- Can observers make accurate inferences about emotion?
- Do observers from different cultures interpret facial expression differently?
- Are observers influenced by contextual knowledge in their judgments of the face?

We have taken almost the opposite position. Rather than requiring the user to learn the mechanics of facial movement, we emphasize the consequences of movement, that is, the perception of a static expression. A FACS mapping would be too complex in terms of effort and resource requirements for the Affective Guide. We are not interested in modelling facial muscle movements or in providing a comprehensive set of facial changes. Additionally, the AUs would be impossible to replicate using a 2-dimensional face.

Facial behaviour has been commonly categorised using two judgment procedures: *categorical*, involving basic emotion categories and *dimensional*, involving scales or dimensions that underlie the emotion categories. A particular emotion can usually be represented by more than one facial expression, depending on intensity, and the discrete approach suffers from the flaw of rigidity, with its one-to-one mapping. The dimensional approach eliminates this restriction, conveying a wider range of affective messages. Using the dimensional approach, the only consistent finding across experiments for classifiying facial behaviour is the pleasant-unpleasantness and activation or intensity dimensions [Ekman et al., 1982]. The evidence for any dimension beyond that is weak.

In Russell's terms, these two dimensions represent general features common to many different emotions [Russell, 1997]. Each emotion category covers a fairly large region of the space and has prototypical pleasure and arousal values. If necessary, the distinct points on the space can be named to reveal the specific emotions as in the *Circumplex Model* [Russell, 1980] where emotion names spread in a circular fashion. He suggested that human beings are able to make quick judgments about quasi-physical behaviour and about pleasure and arousal. He added that it is this primary information, combined with situational context, that determines which, if any, specific emotions the observer assigns to the expresser. Consequently, the pleasure-arousal dimension can be seen in many attempts to map facial expressions to emotions (eg. Breazeal [2003], Russell [1997], Grammer and Oberzaucher [2006]), with some extra dimensions such as stance, dominance, etc., relevant to the context of each research.

Breazeal [2003] built a robot called *Kismet* that has the ability to express nine emotions through its facial expressions, generated using an interpolation-based technique over a 3-dimensional space. This approach is similar to the work of Smith and Scott [1997] in terms of the three mapping dimensions (arousal, valence and control) where *control* roughly maps to *stance*. *Kismet* has a set of hand-crafted releasers, the antecedent conditions to specific emotive responses with associated *[A, V, S]* (arousal, valence and stance) profiles. Arousal specifies how arousing a factor is, valence specifies how favorable a releaser is, while stance specifies how approachable or friendly a percept is to the robot. The *[A, V, S]* net activates the motor system to generate distinct facial expressions, vocal qualities and body postures. The six basic emotions used sit at the extremes of each dimension: surprise at high arousal, fatigue at low arousal, content at positive valence, unhappiness at negative valence, stern at closed stance and accepting at open stance.

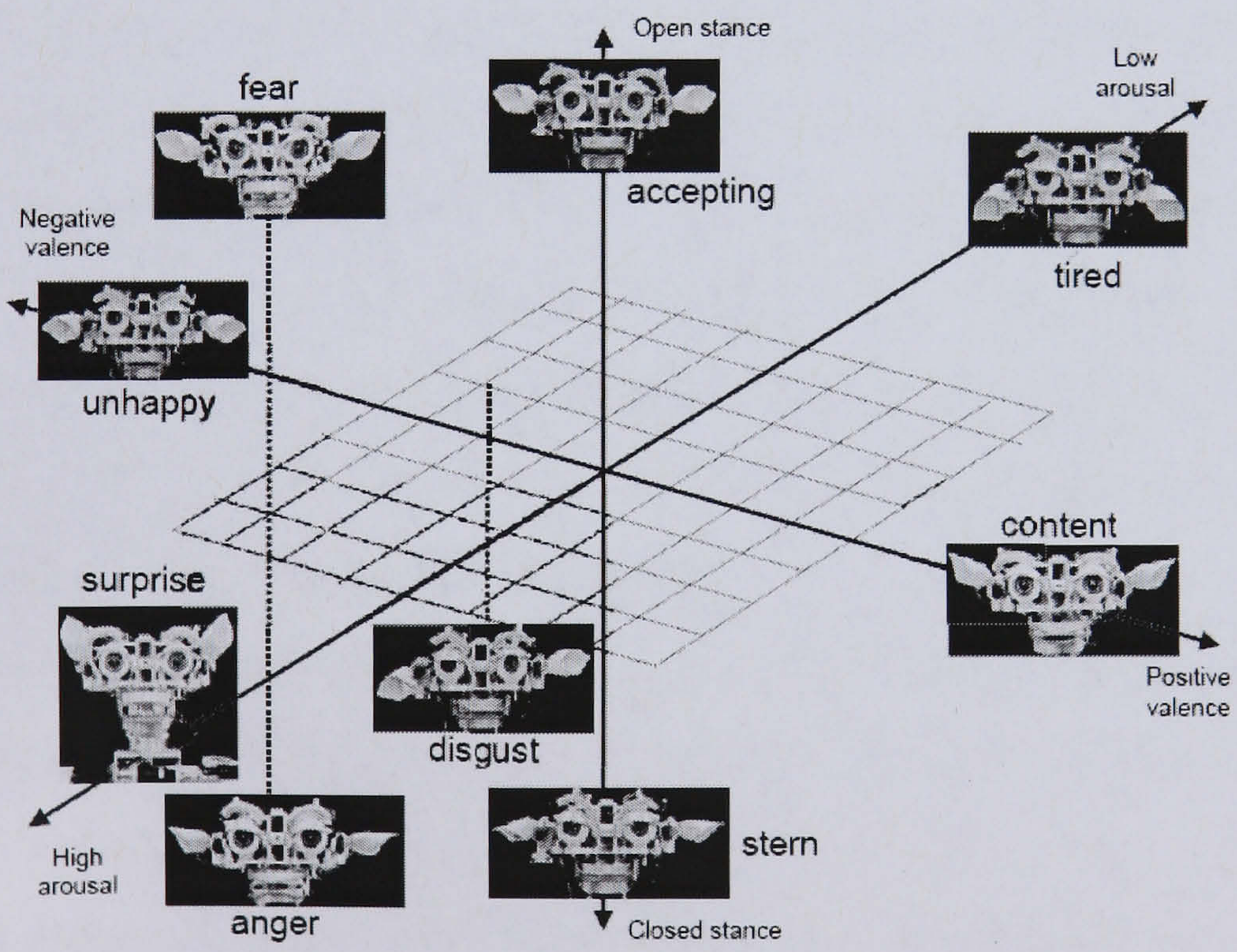


Figure 3.23: The mapping of Kismet's facial expressions and postures to the arousal, valence and stance dimensions (from Breazeal [2003])

Figure 3.23 shows the mapping of *Kismet's* emotions to the arousal, valence and stance dimensions. By blending the basic facial postures, *Kismet* can generate a continuous range of expressions of various intensities but each posture remains local to its region of affect space. Its lip curvature is most strongly influenced by the valence prototypes. *Kismet's* lips turn upward as positive valence increases, accompanied by opened mouth and relaxed eyebrows. In contrast, as valence decreases, the lips turn downward, the jaw closes and the eyebrows knit together. Along the arousal dimension, as arousal increases, *Kismet's* eyes widen, ears perk and mouth opens. High arousal also leads to an erect posture with a slight upward chin while low arousal corresponds to lowered neck lean and head tilt, reflecting a slouching posture. Over the valence dimension, the posture remains neutral. A forward lean movement suggests open stance while shrinking away or withdrawal corresponds to closed stance. As positive stance value increases, the eyebrows arc outwards, the mouth opens, the ears open and the eyes widen.

Breazeal has taken a top-down approach where each facial expression is labelled with an emotion term. We see this approach as inflexible and insufficient to accommodate human complex social interaction signals. Although facial expressions can provide accurate information about the occurrence of pleasant versus unpleasant emotional states, distinctions among particular positive or negative emotions is an issue yet to be addressed [Ekman and Oster, 1979]. Hence, the emotion terms associated with the facial expressions may require further verification. This is not a problem in our case because we do not label emotions, thus, do not require accuracy of emotion judgment.

Russell [1997] provides a bottom-up approach, avoiding the interpretation of facial expression on the level of emotion categories. Russell's mapping of Ekman's facial action units onto the pleasure-arousal space is illustrated in Figure 3.24. From the diagram, it can be seen that displeasure is signalled by downturned mouth and furrowed brows, whilst pleasure is conveyed by smooth brows and an upturned mouth. Lowered eyelids signal lower arousal while widened eyes, raised brows and increased muscle activity are signs of increasing arousal. Table 3.2 provides the pleasure and arousal rating for a subset of representative Action Units, specifying where they should sit in the dimensional space.

Using Russell's approach, Grammer and Oberzaucher [2006] modeled 25 AUs

Figure 3.24: Russell's pleasure-arousal space for facial expression (extracted from Russell [1997])

AU	Description	Pleasure	Arousal
1	Inner brow raised	-1.92	-0.85
2	Outer brow raised	1.85	2.11
4	Brow furrowed	-2.00	1.23
5	Upper eyelid raised	-1.19	3.04
6	Cheek raised	1.46	0.73
7	Lower eyelid raised	-1.85	0.58
9	Nose wrinkled	-2.33	2.33
10	Upper lip raised	-3.67	1.97
15	Lip corner depressed	-2.26	-0.63
17	Chin raised	-0.93	0.60
46	Wink	1.19	0.54

Table 3.2: Pleasure and arousal rating for Action Units

as a system of morph targets on 3-dimensional faces. A program called *Face Randomiser* randomly alters the intensities of activation of these single morph targets to generate different facial expressions. In a study, observers gave pleasure and arousal ratings to the single facial muscle components on the facial expressions displayed by the *Face Randomiser*. The regression factor scores for pleasure and arousal on the single muscles were calculated and an activation space of these muscles in Russell's *Circumplex Model* was developed. A distinct point in the pleasure-arousal space of the combined planes for all muscles can then be interpreted as communicating a specific emotion. Figure 3.25 illustrates the reconstruction of facial expression along the pleasure and arousal dimensions.

The authors later calculated the pleasure and arousal spaces for the categorical emotions from the AUs to verify that the *Expression Program* and the *Circumplex Model* can at least be theoretically unified. They found multiform distribution of categorical emotions in the pleasure and arousal space. Surprise occurs when pleasure is neutral and arousal is high; happiness occurs when pleasure is high and arousal is slightly above neutral; sadness occurs when pleasure is low with slightly raised arousal or when arousal is low and pleasure is high; fear occurs when pleasure is low and arousal is high or medium; disgust occurs when pleasure is low and arousal is high; and anger occurs when pleasure is low and arousal is high or when pleasure is high and arousal is low. Hence, the resulting emotions can occur within contradictory contexts, for example feeling angry under happy circumstances. As the authors state, this is just an exploratory work requiring refinement. Even so, it serves as an inspiration to our research because this approach can generate virtually endless combinations of facial expressions.

Figure 3.25: The complete reconstructed pleasure and arousal space (from Grammer and Oberzaucher [2006])

A much simpler implementation can be seen in [Schubert, 2004]. Schubert developed *EmotionFace*, a software interface to display emotions expressed by music. A simple schematic face with eye opening representing arousal and mouth movement representing valence is used. Both eye and mouth changes are calculated based on parabolic functions. A high arousal will increase the eye opening while a low arousal will reduce it. A positive valence deepens the mouth up-concavity while negative valence flips the mouth in the opposite direction.

Other facial animation engines are GRETA [Pasquariello and Pelachaud, 2001] and the system of Ken Perlin[1]. Briefly, GRETA is MPEG-4 compliant and adopts a pseudo-muscular approach where its facial expressions are controlled by Facial Definition Parameter set and Facial Animation Parameter sets. Additionally, it talks and is APML-compliant. On the other hand, Ken Perlin's *Responsive Face* models a subset of Ekman's FACS on a simple 3-dimensional face.

3.6 Summary

This chapter covers the different notions of emotions proposed by researchers from different academic settings. It includes the view that emotions involve strong reactions of many bodily systems; that emotions can simply be a state of mind or a state of preparation to act; that emotions are triggered by one's interpretations of events; that emotion displays communicate information from one person to another; that emotions help the individual to adapt to the uncertain environmental situations; and that emotion activation cum expressions are influenced by genetic mechanism. Obviously, these approaches offer different insights. The decision to follow one or the other depends greatly on the specific goals and purposes of these models and the application in which it will be applied.

The non-cognitive models operate at a non-symbolic level which is too low for the Affective Guide framework. The guide requires cognitive capabilities for planning and storytelling. In contrast, the appraisal theories perceive emotions as arising from a certain kind of cognition, with little or no attention to the other important aspects of emotion such as the physiological, behavioural and

[1] http://mrl.nyu.edu/ perlin/experiments/facedemo/

expressive components. Operating in a real world environment means having to deal with many uncertain circumstances, hence, an architecture that is flexible and robust is necessary to allow the agent to cope with uncertainty, react to unanticipated events and recover dynamically in the case of poor decisions. The guide needs to have motivations and an adaptive behaviour. It has to learn from experience, perform planning and possess language capability.

We opt for an architecture that blurs the boundary between body and mind. We desire flexibility and rule out the models that define emotions explicitly. Hence, we view the hybrid architecture as the most appropriate. We argue that the agent cognitive processes should result from lower-level physiological processing and the outcome of cognitive processes should influence the agent's bodily states, producing complex behaviours that can be termed emotional. Therefore, we have chosen the 'Psi' model as the basis for the Affective Guide architecture, but with modifications discussed in Chapter 6. Furthermore, in order for the Affective Guide to tell interesting and believable life stories, we stress on the importance of emotional memories. Additionally, inspiring approaches to facial expressions have been reviewed.

Chapter 4

Emotions and Ideology

If you live among wolves you have to howl like a wolf.
- *Russian Proverb*

He who confronts the paradoxical exposes himself to reality
- *Friedrich Durrenmatt. Swiss Playwright and Novelist, 1921-1990*

He who controls the present, controls the past. He who controls the past, controls the future.
- *George Orwell. English Novelist and Essayist, 1903-1950*

There are a number of influential factors affecting human decision making. Human nature has needs that have to be satisfied in some way. Our internal moral system tells us that there are some things we can and cannot do. Our learned nature makes us believe certain things and live in certain ways. Our action may also be driven by the environment and the beliefs or norms of our society. Our emotions can be the reason for our action in certain situations. All these factors are either in conflict or complementary to each other.

So, how are these factors related? How do beliefs influence emotions, and in turn emotions influence beliefs? According to [Lazarus, 1991, Eysenck, 1992, Frijda et al., 2000], there are bi-directional effects between beliefs and emotions. However, most of the research up to the present has focused on the influence of beliefs on emotions and not the opposite. In this chapter, we explore the effect of emotions on beliefs, hence on the individual's ideology.

First, we provide our definition of ideology. We then present the current view of emotional influence on beliefs. Next, we put forward our proposal of the relationship between emotions and ideology. Based on our definition of ideology and the current view of emotion-belief relationship, we suggest the existence of a feedback loop between emotions and ideology in Section 4.3. An individual's ideology may lead to activation of different goals under different circumstances. Emotional impulse may then act upon these goals, leading to certain actions. The consequences of these actions in turn shape the individual's future beliefs. When these beliefs receive acknowledgement from society, they will gradually become the individual's firm ideology. We present two example scenarios of this causal effect to support our standpoint. We also demonstrate how emotions influence the Affective Guide's beliefs in Section 6.3 of Chapter 6 after the functional logic of the emotional model is discussed.

4.1 What is an *ideology*?

Classically, the term *ideology* refers to "the systematic exposition of what purports to be theoretical knowledge claimed by its advocates to be indispensable to rational conduct in social, economic and political life" [Manning, 1980]. As reviewed by Manning, this classical formulation of ideology was first applied to the study of the science of ideas by French materialist Destutt de Tracy at the end of the eighteenth century. Later, Marx and Engels [1848] redefined the term as "a systematic attempt to demonstrate the rationality of the existing distribution of wealth and the social utility of the order in which the wealthy hold positions of power". The most influential use of the term *ideology* after Marx is that of Manheim [1936]. Manheim agreed that *ideology* is a view of reality for those with a vested interest in the survival of the existing social order, but cannot be a basis for 'rational' action by the underclass. On the other hand, his follower, Stark [1958], holds that all forms of thought are socially conditioned, but that ideology has the unfortunate quality of being psychologically deformed by the pressure of personal emotions.

In the recent period, more and more definitions of *ideology* have been formulated. To list a few: *ideology* has been defined as the process of production of meanings, signs and values in social life; a body of ideas characteristic of a particular social group or class; ideas or false ideas which help to legitimate a dominant political power; systematically distorted communication; forms of thought motivated by social interests; identity thinking; socially necessary illusion; the conjuncture of discourse and power; the medium in which conscious social actors make sense of their world; action-oriented sets of beliefs; the indispensable medium in which individuals live out their relations to a social structure; the process whereby social life is converted to a natural reality; and a particular kind of thought [Eagleton, 1991]. According to the Oxford Advanced Learner's Dictionary, *ideology* is "a set of ideas or beliefs that form the basis of an economic and political theory that are held by a particular group or person".

It can be observed that not all these formulations are compatible with one another. Thus, it seems appropriate not to look for a definition but to decide upon one. In this research, the term *ideology* is defined as *"systems of belief held in a society which enable and validate action"*. An ideology defines the shared view of a particular group of people on matters of concern, which later both causes and justifies their actions. We do not link *ideology* with reality or unreality but simply see it as a body of thought held by a social group, thereby avoiding illusion and rationality issues.

In terms of its application in the prototype Affective Guide, from a story standpoint, *ideology* refers to the opinions held by the different groups of Los Alamos' inhabitants on atomic bomb development and deployment. These differing beliefs will explain why each group reacted in a distinctively different way to the same situation during the Manhattan Project years. Each guide is a representative of a particular group depending on its role, for example, civilian or military personnel. On the other hand, if we assume the guides themselves form a social group, *ideology* denotes the guides' beliefs about the user's interests and how they should act to ensure the user's enjoyment during the tour.

4.1.1 Why *ideology*?

So, why is ideology important? How does it affect an individual's behaviour? What role does it play in an individual's outlook on life? Ideology determines why people do certain things and explains why things happen in the way they do. It embodies how the individual believes the world to be, how events are believed to have come about, and what implications events are believed to have. It forms a basic world model, helping us to predict as well as understand things that are going on around us and serving as a template for action planning. Ideology increases the level of certainty of our predictions about the world. It helps us to be certain about our own actions and shapes our reactions to life situations.

> "...Belief in reality of any and every kind rests upon and, directly or indirectly, is induced only by, resistance to our effort, to our own striving. That which can resist us physically or otherwise, can act upon us compulsively, is real, is believed in ... " *W. McDougall, 1934*

Origins of ideological beliefs lie in the inherent cognitive ability of individuals to manipulate beliefs, by adaptation, generalisation or a 'generate and test' process in a heuristic manner. An ideology is a framework of expectations resulting from large scale social interaction. The way of interpreting our world is influenced by our own attitude, as well as evolving from our actions, interaction and communication with others.

Bandura [1997] pointed out that individuals tend to form their behaviours around the behaviours of other people assumed as social models. This is because human nature includes the need to be accepted and to belong to a particular group, as reflected by the Russian Proverb at the beginning of this chapter. Similarly, individuals themselves can act as a model for imitation, indirectly placing pressure on others by means of their actions, implying a bi-directional process between individuals and groups. The higher the individuals' group consciousness, the stronger impact social influence has on the individuals [Boninger et al., 1995], thus, the higher their compliance with intra-group obligations. As a consequence, it also seems likely that a significant impact of ideology is to coordinate the actions of people and to limit, in effect, their individual autonomy by creating 'social norms', so enhancing survival.

4.2 Emotional Influence on Beliefs

As mentioned earlier, research on the influence of beliefs on emotions has been going on for some time. With the emergence of "cognitive emotion theory" [Lazarus, 1991], beliefs are viewed as major antecedents of emotions. Beliefs become one of the major determinants of emotion and hence, important to the study of emotion. Appraisal theory [Scherer, 1999] further emphasises this point, taking emotions as resulting from individual beliefs about the world, about the occurrences of events and about the implications associated with these events.

Surprisingly, the reverse direction of influence between emotions and beliefs has received scant attention although this influence was traditionally considered as one of the most important feature of emotions. The classical assumption states that emotions influence beliefs, implying that emotions determine our thinking and what we think is true. For the Stoics, emotions are "judgment about the value of things incidental to an agent's virtue" [de Sousa, Spring 2003]. Aristotle stressed that emotions have great importance in moral life. In Rhetorica, he viewed emotional arousal as vital in the persuasive formation of judgment, "... for the judgments we deliver are not the same when we are influenced by joy or sorrow, love or hate" [Aristotle, 1941], reviewed in [Frijda et al., 2000]. Furthermore, according to Spinoza [1677], "emotions are states that make the mind inclined to think one thing rather than another" and this is what makes the difference between the best and the worst lives.

Even in Stark's definition of ideology, "...ideology has the unfortunate quality of being psychologically deformed by the pressure of personal emotions like hate, desire, anxiety and fear" [Stark, 1958], we can deduce that there is some impact of emotions on an individual's belief, in spite of the fact that this formulation of *ideology* is pejorative. It is only in the last thirty years or so that empirical research has established that affective states have a great influence on both the content of cognition and the cognitive processes which are extensively involved in the creation and maintenance of beliefs [Forgas and Bower, 1987, Forgas, 1995, Sedikides, 1994]. The former view of 'emotion as an irrational element that distorts cognition' has been overturned by findings from [Damasio, 1999, Lazarus, 2001], etc. Roseman and Smith [2001] suggest that appraisal may be the cause of emotions, a component of emotion and a consequence of emotions. Emotions have also been described as complexes of beliefs, desires and feelings [Oakley, 1992].

4.2.1 Emotional Influence on Individuals Beliefs

Walsby [1947] pointed out that although beliefs may guide our actions, they are not sufficient to initiate action without the presence of an emotional impulse, the essential switch that turns a thinking being into an actor. Sharing the same view, Brand [1984] argued that thinking, no matter how well articulated, is insufficient for action.

Clore and Gasper [2000] suggest that feeling is believing, in that beliefs are adjusted to be compatible with internal evidence, feelings, just as they are adjusted to be compatible with external evidence from perceptual experience, seeing. Affective influence on beliefs is suggested as involving two processes: attributional effects and attentional effects. Attribution effects usually occur in moods when the affective state has no 'obvious' object, leading to its misattribution to a substitute object. Such attribution may form a new belief or validate prior belief about the object. Attentional effects on the other hand, are due to selective focus or narrowed attentional focus leading to extreme belief and risky action. Unlike mood, emotions have an object. In addition to serving as evidence for belief, emotion may commit one to a belief, for example, being fearful is commitment to belief that one is in danger.

According to Heise [1979], affect constrains beliefs and vice versa, that is, strong feelings tend to evoke a search for supporting beliefs, and highly evaluative beliefs about something are usually capable of arousing strong feeling. Supporting this argument, Clore and Gasper discussed Neisser's "perceptual cycle" [Neisser, 1976]. By equating Neisser's terms of 'schema' and 'exploration' to 'belief' and 'attention', they envision a three-part cycle where belief directs attention, which influences the sampling of information, which in turn modifies the belief. Clore and Gasper added that this framework can be applied to both environmental search or to memory search as illustrated in Figure 4.26, in accordance with their idea that emotion guides attention towards belief-relevant information and elicits belief-consistent recall.

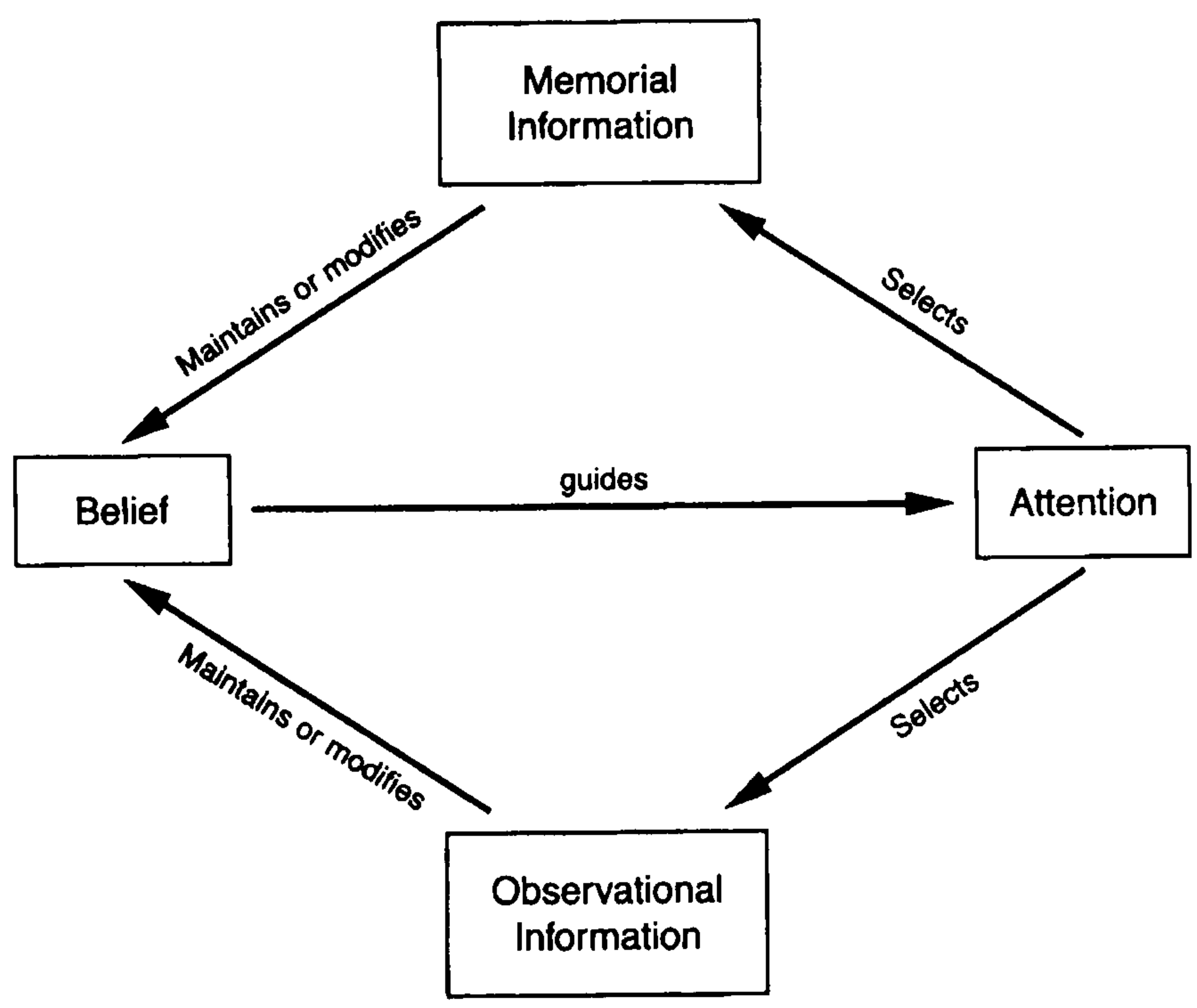


Figure 4.26: Perceptual cycle of belief and attention (from Clore and Gasper [2000])

According to Frijda [1993a], emotions include the formation of beliefs and often provoke the elaboration of those beliefs. Consequently, emotions are not one-shot reactions to antecedent perceptions or beliefs, but involve cyclical processes. Frijda and Mesquita [2000] showed that emotions may give rise to beliefs where none existed or change existing beliefs, and emotions may enhance or decrease the strength of a belief. Emotions are believable because they arise from within, and are directly present to the senses. An emotion-belief spiral exists in which emotions generate concepts that sustain certain beliefs, which in turn further support emotions and so on. In other words, emotions awaken, intrude into, and shape beliefs. Conversely, beliefs constitute the meaning attached to events and hence are part of emotions.

Frijda and Mesquita make the point that the establishment of sentiments or the formation of persisting beliefs is mediated by emotion anticipations, the prevision of actual emotions that might emerge under imagined circumstances. They go further by suggesting that emotion anticipations are probably what maintains or strengthens these long-term beliefs when these beliefs are challenged by contradicting information. Beliefs are prolonged and gradually become more solid and persistent by the process of rumination and amplification [Petty et al., 1995, Tesser et al., 1995].

The influence of emotions upon belief can also be explained using the four features of emotionally-steered thinking: instrumentality, motivational force, control of the scope of thought and motivated bias. Emotions can generate functional beliefs that help to achieve emotional goals such as increasing one's sense of competence, making one feel better or getting rid of dissonance as demonstrated by Harmon-Jones [2000]. Emotions urge on beliefs and strengthen their resistance to change because abandoning a belief may hinder one's readiness to act and challenge one's sense of security. In addition, emotion-charged beliefs are resistant to change, because emotional arousal focuses attention upon information that is directly relevant to them, and removes unrelated implications. Emotional thinking is also biased toward beliefs that support one's emotional aims, and toward memory search and construction of beliefs that correspond to them [Kunda, 1990] as long as reason permits this. It is argued that it is unlikely for people to believe in something that completely overturns existing beliefs. This affective bias in thinking influences the probability, credibility and plausibility of a belief leading to a situation where certain beliefs allow one to maintain illusions.

Forgas [2000] suggests that affective influences on cognition and beliefs are best understood in terms of a multi-process theory in which different information processing strategies are used in response to different situational conditions. "The process whereby affectively loaded information exerts an influence on and becomes incorporated into a person's cognitive processes, entering into their constructive deliberations and eventually colouring the outcome in a mood-congruent direction" is termed as 'affect infusion'. Two mechanisms of affect infusion are proposed. The first is the affect-as-information model that occurs when circumstances require quick, simple, heuristic processing where affect itself serves as information. The second is the affect-priming model where affect primes attention, encoding, retrieval and selective use of information, usually takes place during substantive and elaborated processing. Forgas [1995] found that mood-consistent information takes longer to encode compared to mood-inconsistent information. Nonetheless, mood-consistent judgment can be made more quickly than mood-inconsistent judgment probably due to the better prior encoding. Additionally, recall and recognition of mood-consistent information are superior to mood-inconsistent information. Distinct processing consequences can also result from affect itself whereby negative moods are more likely to promote systematic, externally focused, accommodating processing while positive mood tends to produce top-down, assimilative processing.

Fiedler and Bless [2000] proposed an affective-cognitive behaviour regulation mechanism with positive affective states fostering assimilation tendencies but negative states triggering accommodation processes, confirming Forgas's findings. Assimilation is a top-down cognitive-driven process which encourages the application of prior knowledge structures, while accommodation is a bottom-up stimulus-driven process that adheres to the input data as carefully as possible. According to Fiedler and Bless, the assimilative power of positive mood supports reliance on and elaboration of the existing belief system while the accommodation function of negative states questions and weaken beliefs, allowing belief systems to be updated in the light of new significant data, preventing illusions. This is due to the fact that people in negative states tend to be more cautious and careful in decision making, leading to a detailed observation process and highly systematic diagnosis. In contrast, a joyful person leans on knowledge-based inference, detached from stimulus constraints, arriving at a conclusion much more promptly [Forgas, 1995].

The relationship between anxiety and beliefs has been explored by Eysenck [2000]. He argues that there are several biases associated with anxiety: selective attentional bias, which involves preferential attention to threat-related stimuli; interpretive bias, which involves interpretation of ambiguous stimuli in a threatening fashion; and memory bias, which involves a tendency to threat-related information retrieval. Eysenck stresses a bi-directional influence between anxiety and schemas, where anxiety leads to threatening belief structures that in turn increase the experience of anxiety. Therefore, highly anxious individuals tend to believe that the world is a dangerous place and that they are vulnerable. However, he added that there are still major unresolved problems in this area of research that require further study.

Other interesting work has been carried out by Harmon-Jones [2000], based on Leon Festinger's theory of cognitive dissonance [Festinger, 1957] which states that "the presence of a cognitive inconsistency of sufficient magnitude will evoke a negative emotional state that will motivate cognitive work aimed at reducing the cognitive inconsistency". Harmon-Jones characterizes the dissonance process as adaptive, where negative affect motivates attempts at discrepancy reduction to support the commitment but if dissonant information is above a particular threshold, the negative emotion may motivate the individual to discontinue the commitment and the most adopted solution is by changing attitudes or beliefs to be more consistent with the current situation.

The view is comparable to Frijda and Mesquita [2000] and Forgas [2000] arguments that negative affect facilitates accommodation. Moreover, Boninger et al. [1995] propose that in order to minimise discomfort caused by discrepancy, beliefs that are inconsistent with other strongly held beliefs may be downgraded in their importance. The degree to which individuals believe the information aids them in outcome prediction in order to behave effectively or the degree of commitment directly determines the resistance to change. Besides belief change, dissonance may also lead to explaining the disconfirmation by adding new cognitions, which according to Harmon-Jones, implies the formation of new beliefs to justify feelings and actions. However, there exists little research on this domain due to the difficulty in demonstrating the lack of belief prior to new belief formation.

4.2.2 Emotional Influence on Social Beliefs

While most studies to date looked at connections between emotions and beliefs about individuals, Oatley [2000] and Clark and Brissette [2000] have taken it a step further by including the social perspective. Oatley [2000] studied the influence of emotions, particularly long-term emotions on beliefs in distributed cognition, including social distribution, externalisation and temporal distribution. Long-term emotions are what Frijda termed 'sentiments'. Oatley argues that sentiments play a role in structuring our relationships with others and with certain objects, at the same time affecting our beliefs about them and the plans we make. Social goals of affiliation, attachment-security and dominance were considered. Examples of the associated sentiments are affection, warmth, enthusiams, empathetic identification, and so on, of which each has an associated belief, which is absent without that sentiment. With warmth and affection there is trust, with enthusiasm there is hope and with empathetic identification there is a belief in purpose. Such beliefs alter people's reaction to shared tasks, people's commitment to externalized cultural object and to enculturation.

The influences of emotions on beliefs in a social setting was also explored by Clark and Brissette [2000] emphasizing interpersonal relationships. They based their arguments on two simple assumptions: experiencing and expressing emotions is vital for communication of need states [Frijda, 1993b]; and the extent to which members feel responsible for one another's needs defines the type of social relationships [Clark and Mills, 1979]. They address the two-way connections between beliefs and emotions: first, how beliefs about our relationships with others influence the expressions and experiences of emotions and second, how these emotions expressions and experiences influence beliefs about our relationship.

According to Clark [1984], in a communal relationship, members feel a greater amount of responsibility for the welfare of others than in other forms of relationships. In other words, there is a belief in communal obligations to each other and communal relationship, especially stronger ones, involve more emotional expressiveness giving rise to more emotional experience. Furthermore, Clark and Brissette observed that the expression and experience of emotions in different social contexts, convey different meanings about people and relationships. Emotions expressed within communal relationships lead to more positive beliefs about others and promote relationships, parallel with Oatley's notion of positive sentiments that afford cooperative relationships. In contrast, emotions expressed outside communal relationships lead to more negative judgments about the others and the relationships. Emotion expressed outside communal relationships may also be taken more seriously.

4.3 Our View on Emotions and Ideology

It is very obvious now that both emotions and beliefs interact with each other to guide human action and decision making. So far, we have seen that emotions play an undeniably important role in many aspects of our life: judgment, thinking, action, attention, communication, processing, behaviour regulation, beliefs formation or elaboration, and so on. They may prevent or promote certain actions in a particular situation. On the other side of the coin, an ideology bundles emotions, actions and ideas into one amalgam, so that one does not know where the emotion ends and the idea begins [Waxman, 1968]. The difference between an individual's beliefs and ideology is that the latter involves social interaction. Ideology makes people believe that they are acting with some authoritative sanction.

The power of ideology to lead emotional action is remarkable [Frijda, 2004]. Violation of a major ideology tends to produce strong emotions which encourages actions. According to Frijda, whether or not an action follows emotions depends on the acceptability and availability of an action, the importance of the emotion or issues at hand and the susceptibility of these factors to social influence. People will not usually accept someone walking over their ideological principles and may come to blows when their ideologies are contradicted. Ideology provides a confirmation to an individual's behaviour when the individual is feeling insecure. Hence, there is a common source of emotional satisfaction behind all modes of ideology.

Since emotions impact individuals' judgments and beliefs, and since ideology is a system of beliefs, we propose that emotions must have an influence on ideology. It has to be emphasised that research in this direction is still lacking, probably due to the formation of ideology over a long period of time and the difficulty in obtaining convincing evidence about ideologies possessed by individuals. In Walsby's account, in addition to the cognitive aspect, the emotional aspect is an essential and necessary ingredient of all ideologies [Walsby, 1947]. He refers to the cognitive aspect as a set of logically implied assumptions whereas the affective aspect is a set of emotional ties or identifications with varying intensities. Each aspect involves two elements: positive and negative. Positive assumptions are implied by acceptance of certain propositions, while negative assumptions are reflected in the denial of certain propositions. Assumptions undergo a continual modification process corresponding to internal and external conditions and the more permanent the assumptions, the longer the process takes. On the other hand, negative identifications are implied by emotional repudiation of certain ideas, things or person, while positive identifications are implied by emotional acceptance of those subjects. These two aspects are said to be complementary and condition each other.

Establishment of ideologies involves transformation of negative assumptions and negative identifications to positive assumptions and positive identifications respectively. Certain limitations (assumptions) have to be accepted to overcome greater limitations otherwise suffered, leading to a sense of pleasure. Conversely, emotional identifications serve to establish main assumptive structures. Since each individual has some kind of intellectual and emotional life, expressed through his or her behaviour, Walsby concludes that everyone has an ideology though not exactly the same one, as there are no two individuals who have exactly the same structure of cognitive assumptions and affective identifications. Despite the differences, there exist common features among individuals' ideologies that allow their classification into groups.

Adopting Frijda and Mesquita's idea of an emotion-belief spiral, we suggest that ideology may result from a similar cyclical process, in which temporary belief among members of society goes through rumination and amplification, becoming more and more solid and widespread, finally turning into persistent ideology. Its structure and development is achieved through communication of ideas or beliefs among a group of people. As consequence, the formation of ideology may be more gradual compared to belief because the spread of a particular view among people takes time. However, in the case where emotional pressure for group loyalty is high, the opposite may be true, where an ideology is implanted into an individual without much resistance.

In the following discussion, we justify our standpoint using two example scenarios: from a political position and an everyday situation. An individual's outlook on life depends very much on his or her emotional attitude and social surrounding. One tends to believe rumours that are consonant with one's emotional attitude [Frijda and Mesquita, 2000]. That is, we pay attention to what interests us. This is consistent with the mood congruence effect [ICRA, 2005] whereby we remember events that match our current mood. Thus, depicting information or ideas from an emotional perspective that is parallel to the listener's emotional states makes slipping a belief into the listener's mind easier as emotions are evoked.

This use of emotions to infuse ideology is common in political stances. Emotions are used to induce a belief change in society and adds strength to the new belief. For example, in the case of the creation and employment of the atomic bomb during World War II, initially, there might be many groups among the Manhattan Project with contrasting ideologies. Let's consider two of them. Those that believe the creation and employment of the atomic bomb is necessary to end the war and save lives, mainly the military community, versus those who oppose the making and use of atomic bombs with the belief that the destruction it will bring to the world outweighs gain; mainly the scientists.

But what makes one ideology outperform the other? Why do some of the scientists conform to the military community view in the end? The Japanese were viewed as completely inhuman, as depicted by American propaganda. This evoked anger and fear by focusing on the negative effects of the war, the cruelty of the Japanese, the number of friends and relatives killed, the amount of money and resources spent, etc. Japan was depicted as very far from surrender and the war as continuing for a long time. This led to a firm belief in the enemy's evil nature, because we usually think evil of those whom we fear [Frijda and Mesquita, 2000]. The creation of the atomic bomb, thus, sustains hope. In addition, the recruiting slogan of the Manhattan Project was *"Help win the war to end all wars"*. All those who were involved in the project are induced to believe that the availability of fearsome atomic energy will create the view that wars will be much too horrible and there could never be another war [Hirschfelder, 1980]. They are made aware of the necessity of stopping Hitler and the Japanese from destroying the free world.

Here, ideology comes in to bridge the emotional gap between things as they are and as one would have them be. The emotions aroused call forth some effort to overcome the undesirable situation and provide a justification for the destruction of the enemy. This emotional goal consequently results in motivated bias in order to get rid of dissonance as Harmon-Jones [2000] put it. Hence, beliefs that were inconsistent with the goal are downgraded in their importance to minimize the discomfort caused by the inconsistency. Emotions narrow the focus of attention to the goal at hand, that is destruction of the enemy, leaving little attention for consideration of the consequences of that action.

Furthermore, the making of the atomic bomb evoked pride among the scientists. It provided emotional cohesion to the laboratory staff and the scientists in the Manhattan Project. They were continuously told that the whole fate of the civilized world depended upon their succeeding before the Germans. The successful creation and employment of the bomb would prove to the world that they were the first to succeed, hence superior. Emotional need for competence and fear of losing to the Russians and Germans sped up the creation process and switched their attitude from opposition to affiliation.

Additionally, in a situation of isolation in the Jemez Mountains of Los Alamos, agreeing with the dominant group ideology is the most sensible choice. It is the least dangerous option. The emotional pressure of loyalty to the group would have been potent. Group membership is a very powerful and emotionally involving experience and since the scientists considered themselves as part of the Manhattan Project, they were motivated to conform. Many beliefs in emotions do not so much help to modify the emotional event, but one's sense of competence in the given relationship [Frijda and Mesquita, 2000]. Divergence from the group may have an undesirable impact on the individual's life as well as their relationship with others. In other words, the individual sense of security will be threatened. In order to maintain stability, group conformity may be the best alternative as long as it does not harm the individual's sense of being true to themself.

When the individual's self-commitment is impaired, he may choose to betray the group as in the case of Klaus Fuch, a member of the Theoretical Physics Division who became the central figure in a great espionage scandal. Understanding the growing disappointment among the scientists in failing to prevent the deployment of the bomb is necessary to judge his thoughts and actions. He was guilty according to contemporary moral ideas of loyalty, but loyalty is also something to be shown to humanity as a whole, not only to one individual against others. How could a man act when confronted by circumstances against his will, with the problem of the best use of power here and in this world?

Apart from political stances, emotions also influence our ideology in social settings and daily activity. For example, perhaps you are taught since young that helping those less fortunate than yourself is good. You hold onto the ideology that the fate of the less fortunate has been determined when they are born and it is an unalterable fact of the natural condition of mankind. Affective empathy [Davis, 1994] or more specifically, empathic compassion is present where you share their despair and struggle. Hence, everytime you see a beggar on the street, an emotional impulse initiates you to give him some money. You are certain that what you do is good for the beggar, society and yourself. You feel satisfied with your actions and believe that the beggar is going to utilize the money in the best way he can. You feel socially competent as it is an act approved by society.

One day, a few "blind old men" were sitting along the roadside begging. Out of kindness, you donated some money to them and walked away happily thinking that you have done another good deed. A few moments later, you see the same group of old men, now without their sunglasses, sitting in a posh restaurant, enjoying themselves. What will you feel? The perceptual information you received is in conflict with your active ideology. The old men's behaviour conflicts with your prediction. You feel cheated. Negative emotions, anger and disappointment are aroused. In order to reduce this discrepancy, you may alter your mindset about the less fortunate, or come up with an explanation for that specific situation. If this incident has happened for the first time, you might take it as an exception and provide the explanation that these old men were only disguised as poor.

The next time you encounter the same situation, you will be more careful. You will be uncertain about the accuracy of your prediction as your previous experience conflicts with your ideology. If this incident happens again and again, then the anger and disappointment you experience will be enhanced. Each time it repeats, you will be reminded of the previous unpleasant experience as negative emotions lead to substantive processing that results in mood-congruent effect [ICRA, 2005]. Applying the notion of sentiment, the extent to which you are inclined to think that the painful outcome of the action was intentional will lead you to form a negative sentiment which will affect the way you interpret and react in future. Thus, if the negative emotions continue to mount, you will probably start altering your belief, particularly if this view is further confirmed by other members of society. Here, mood repair is taking place.

Furthermore, to disbelieve what we experience is uncommon. It is difficult to erase our sensory experiences from our memory. When we experience an event, we commit ourself to a particular belief about that situation. This may be a reason why an intense emotional event may lead to post traumatic stress disorder because a memory can be retrieved by any of our senses and the file that has a strong emotional value will be the first to be retrieved [Carver, 2005].

In future, you may ignore beggars completely as you expect the same situation of disappointment to happen. You start to generalise that they are not worth helping. Your belief might place pressure on others when you warn them about what happened. If more and more people that held the same ideology as yours encounter the same situation, the shared emotional disappointment may lead to a change of ideology. A switch to the ideology that the less fortunate are at fault for their own condition and poverty might occur. Since they are not willing to work for a better life, why must you lend a helping hand? This thought makes you feel better. Therefore, this new ideology will guide your future action until another discrepancy occurs. This loop continues throughout our lifetime and that is why an individual's thought differs during the different stages of his or her life.

In both the above examples, a causal chain for the formation of ideology exists where emotion is a vital element. When confronted with a certain situation, the cause, that is the ideology, held by an individual will activate a certain goal. This activation combined with the emotional impulse leads to a certain action. The results and aftermath of this action impact the individual's belief, and when the belief receives confirmation or is emphasized by other social members, it determines the ideology which he or she will hold next. If the individual's expectation is fulfilled, some kind of emotional satisfaction is achieved, hence, his or her current ideology is strengthened. In contrast, if discrepancy occurs, leading to frustration, his or her current ideology is weakened and subsequently revised.

Figure 4.27 shows a causal chain for this process. The adjustment to an individual's ideology is a continuous process and it can happen subject to action failure and frustration as well as to the continually changing nature of the environment, both the natural environment and social factors. The resistance to change is determined by the degree to which we commit ourself to a certain ideology or in Clore and Gasper's terms, the intensity of feelings involved. The more emotionally-charged a particular ideology, the stronger our commitment to it and the less susceptible it is to change [Clore and Gasper, 2000].

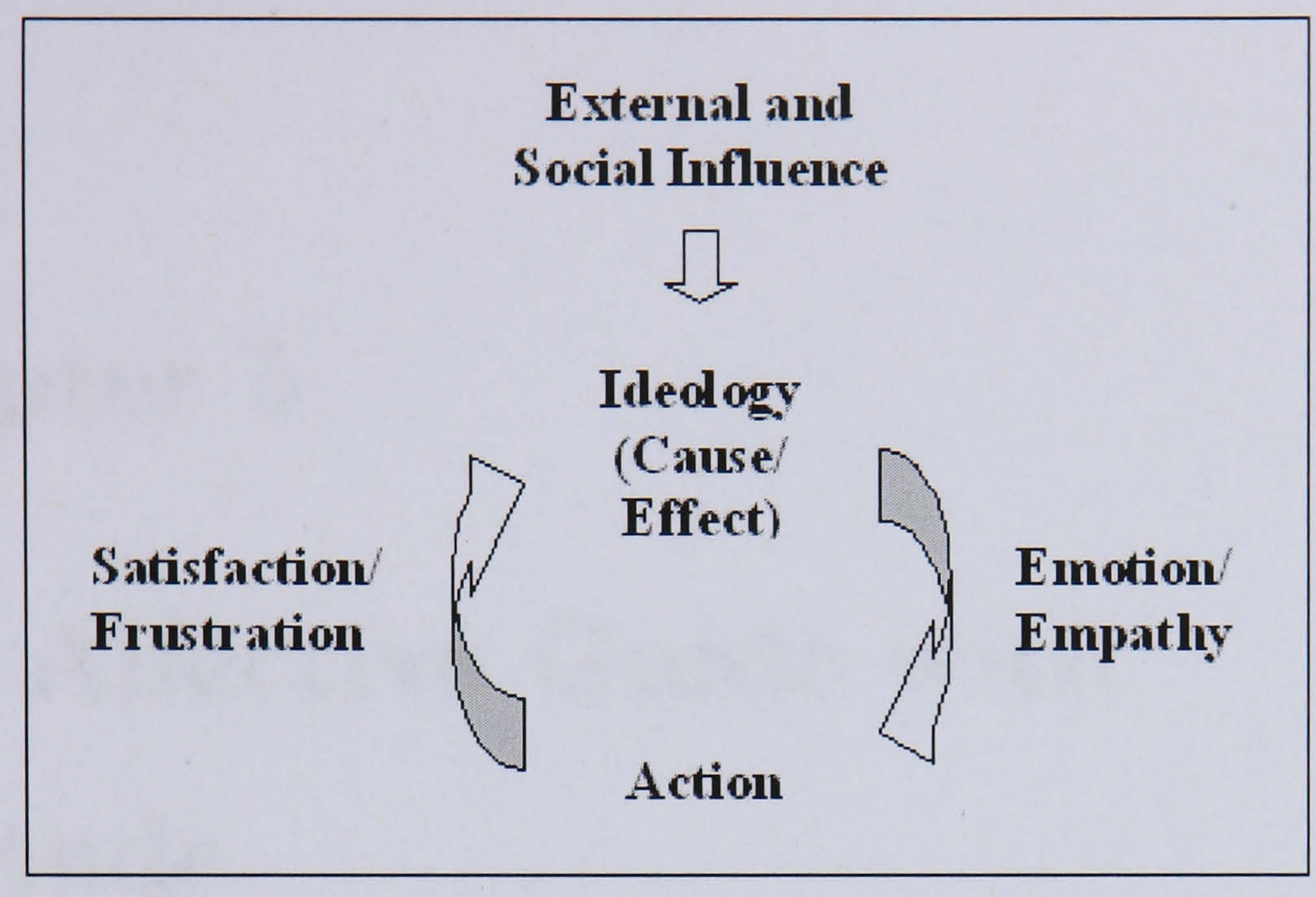


Figure 4.27: Ideology Formation Chain

4.4 Summary

This chapter reviewed some of the current views of emotional influence on beliefs. It is undeniable that there is a bi-directional interaction between these factors since there is no pure cognition. We have also put forward our proposal on the influence of emotions on ideology. An ideology (cause) determines what we believe and an effect is that which we believe. A cause combines with emotional impulse to initiate actions and the resulting emotions determine the effect. This process of ideology moulding in response to different situations and our past experiences is a continuous lifetime process subject to social influence. It follows that emotions play an important role in the formation and elaboration of the Affective Guide's belief about the user's interests that subsequently justify the guide's action. A demonstration of how emotions change the beliefs of the guide is provided in Section 6.3. By adapting behaviour and changing its belief based on its emotional state, the guide is able to response to its interaction environment effectively.

Chapter 5

The Affective Guide with Attitude

Men love to wonder and that is the seed of our science
- *Ralph Waldo Emerson. American Poet, Lecturer and Essayist, 1803-1882*

Take time to deliberate; but when the time for action arrives, stop thinking and go in.
- *Andrew Jackson. American 7th US President, 1767-1845*

There are two ways to live: you can live as if nothing is a miracle; you can live as if everything is a miracle.
- *Albert Einstein. Nobel Prize for Physics in 1921, 1879-1955*

In this chapter we first provide a classification of different types of tour guide (non-human and human) based on our survey. Next, we present the Affective Guide System. We start by giving a technical description of the system, then the functional overview, as well as an explanation of the graphical user interface. Finally, the navigation system and the route planner are presented.

5.1 Types of Tour Guide

Based on a brief survey of tour guide experiences, factors like role, interest, experience, type of tour, length of tour, guide's belief, guide's personality and visitor group are found to influence the presentation of information. Most guides tend to incorporate beliefs and past experiences, whether his/her own or that of others whilst narrating a story. Different guides have different presentation styles and some guides are more talkative than others. Most of the time, they present general information about the tour, particularly about what can be immediately seen. They usually welcome interaction in order to gain an indication of the visitors' interests before they provide in-depth information on a particular subject.

Visitors' age, origin, race and group size also contribute to the type of story told and the level of detail in which it is told. Indoor tours are usually more continuous, while outdoor tours involve more idling moments due to walking from one place to another. Generally, the result of our survey showed five main categories of tour guide, classified based on the following criteria:

- the guide's skills and knowledge
- means for information presentation
- story content
- user's means of interaction and
- the interaction style

Classification details for the different guides can be found in Appendix A. A list of questions and the results of informal interviews with some of the guides are also attached.

Type I represents a passive guide, not a real human guide, where no communication skill is required. An audio guide is an example of a Type I guide. The tour will start with an introduction on how to use the audio device and an introduction to the site. Storytelling continues based on the numbering of the points of interest. The user chooses the story to listen to by pressing the number for the particular point and then the 'Play' button. Hence, the same story will be presented everytime the same button is pressed. Besides speech, there can be background sound or music and the real artefacts or environment features act as visual cues.

A Type II guide is a real human guide with basic communication skills and essential knowledge about a particular subject, for example, art, science, history and so on. Before a tour starts, the guide will usually introduce him/herself. Then there will be a short ice-breaking session during which information about the visitors is obtained and their interests gathered. A Type II guide usually incorporates his/her own perspective into the story and the presentation follows a particular sequence, most of the time chronological. The guide's interests, as well as the users' interests, act as the determining factors for the story content. Therefore, stories presented may vary between one user and another. Communication between the guide and the user is bi-directional because the users have opportunities to ask questions and express their own opinions. From time to time, the guide will ask simple questions to produce interaction that gives hints about the users' interests. As in everyday human communication, body language, eye-contact and facial expressions are all used.

A Type III guide is a variation of a Type II guide, but with more enthusiasm and motivation as well as an extensive knowledge about different places and subjects. Instead of a short tour that ends in less than an hour or at most a few hours, a type III guide is usually a professional guide for a trip that can run from 2 days up to a few weeks. Here, the guide plays the role of a friend and companion. In addition to a simple ice-breaking session, more direct-participation from the trip members is essential to make the trip more interesting and enjoyable. Hence, the guide needs to have a pleasant personality, sense of humour and skills such as singing, dancing, etc. Many tools can be used whether for entertainment or to aid activities carried out throughout the trip. Daily communication takes place. There is no rule for story content, which can range from mere historical facts to opinions, beliefs and myths or even something personal. Communication between the guide and the user is more intimate due to the length of time they are spending together. From time to time, the guide needs to think of different activities and encourage interesting ideas and participation from trip members, creating friendship bonds and mutual understanding among them. Conversation takes place not only between the guide and trip members but also among trip members themselves. The trip members usually have a chance for first-hand experience of the lifestyle and cultural activities of a place or country.

A Type IV guide is also a variation of Type II guide with expert knowledge of a specific subject. The information presentation follows an order and consists of mostly real facts with less perspective information. The interest of the guide and the user is less influential as the story content follows a fixed structure, hence interaction also decreases. Although the main story line remains unchanged, the way it is presented may vary slightly as narration is spontaneous. A type IV guide is usually a professional presenter of stories related to a production process, for example a guide that takes you around a factory or distillery.

A Type V guide is a guide who can produce emotional impact in visitors. In addition to basic communication skills and knowledge about the subject, expressivity and some acting skills are necessary. Expressivity can be employed either verbally or through facial expression. A Type V guide usually employs additional tools or hidden helpers to create the desired story effect. The story combines both facts, beliefs and imagination. In this case, bi-directional interaction is minimised, if not eliminated, to prevent distraction from the effect on the user's emotions. The stories are usually linked smoothly so that the impact can be maximised.

Consistent with our findings, Doyle and Isbister [1999] found that a human tour guide's storytelling reflects the following characteristics: stories are told about a particular location while the location is looked at; stories include materials that the guide reincorporates from previous tours; stories are selected in such a way that it enables easy retelling by visitors to others; and the guide adjusts the storytelling time and follow-up stories based on visitor's interest levels.

Furthermore, Dautenhahn [1998a] classifies narrative agents into four types. A Type 0 agent always tells the same story; a Type I agent tells a variety of pre-defined stories that are not situated in the conversational context; a Type II agent selects the story that fits the current context best; a Type III agent tells and listens to stories, interprets the meaning and content of the story and finds the most similar story in its own story-base which is adapted to produce an appropriate response. Finally, a Type IV agent is an autobiographic agent, a term Dautenhahn reserves for human agents, whose story-telling ability is linked to a living autonomous agent, a real personality.

Based on all this information, Table 5.3 summarises the requirements and the design choices to the creation of a believable and engaging guide:

Requirements	**Design Choices**
Introduces himself prior to tour	A welcoming and ice-breaking session where the guide introduces himself, gives a brief overview about the tour and gets to know the user
Takes visitors around an attraction	A location and an orientation mechanism to aid visitors in navigation
Essential knowledge	Sufficient information in the database for story generation
Timely delivery	Information presentation at the right time and at the right place, so that stories are related to what can be immediately seen
Smooth flow of presentation	Mechanism for linking the stories across the presentation
Bi-directional communication	Means for user input and means for the guide to express himself
Spontaneous presentation	Improvisational storytelling to ensure variation in stories
Behaves appropriately	A regulation mechanism that allows adaptive behaviour
Helps visitors in learning	Informs visitors about what is important; minimises distraction while visitors appreciate the heritage; utilises different means for presentation to ensure maximum information absorption; provides perspective information so that visitors can analyse and draw their own conclusion on a subject
Maintains visitors interest	Tells stories that are of visitors' interests and adjusts stories according to their level of interests; includes interesting life stories
Behaves distinctively individual	Possesses a personality; presents stories that reflect the personality and includes its own interests in story presentation

Table 5.3: Requirements and design choices for a believable and engaging guide

5.2 The Affective Guide

The Affective Guide is a virtual guide and combines elements of Type I, Type II and Type V guides. The main differences between a virtual guide and a human guide concern spatial setting, body expressions and interaction modality. A virtual guide exists and navigates in a virtual world, hence, it does not have the same freedom to move around the spatial location during the guiding session as its real counterpart would. In contrast to the body language and facial expressions of a human guide, its internal states are represented as mathematical values, which can be reflected through a graphical representation. Finally, communication between the user and a virtual guide takes place through special interfaces such as sensors, virtual devices, keyboard input or speech recognition system.

Similar to a Type I guide, the Affective Guide uses an audio presentation but with the addition of a graphical user interface (GUI), discussed in Section 5.2.2. The guide entertains only a single user at a time in an outdoor setting. It tells stories by linking its memories and the user's interests as well as the physical location, so that stories are relevant to what can be immediately seen. Stories are improvised, hence do not follow a fixed order and content may vary based on the user's input.

The guide introduces itself and requests the user's name and interest(s) prior to a tour session as a Type II guide would. It then takes into account the user's interests and its own interests in narration. Simple two way communication exists between the guide and user, where, after each storytelling cycle, the guide acquires simple responses from the user. However, it lacks the ability to detect the user's response through body language, eye contact and facial expressions. The user's input is solely through the GUI and output is received by means of text, speech and visual animation.

In addition to these Type II guide characteristics, the Affective Guide tries to induce empathy in the user. Examples of other empathy-invoking agent research are the VICTEC[1] and ECIRCUS[2] projects. Empathy is a psychological concept that describes an interaction between one person, the 'observer' and the 'inner state' of another person, the 'target'. Most contemporary empathy researchers agree that two different aspects of empathy have to be distinguished: the cognitive

[1]http://info.nicve.salford.ac.uk/victec/
[2]http://www.macs.hw.ac.uk/EcircusWeb/

and the affective aspects. In this research, we are focusing on the cognitive empathy or 'perspective taking' that occurs when the outcome of an empathic process is that the observer tries to understand how the target feels in a given situation [Schaub et al., 2003].

Besides emotions, personality plays an important role in the guide. The Affective Guide tells stories based on its own experiences and points of view. The guide attempts to persuade the user to think in the way it thinks, and feel what it has experienced, that is, to put the user in its own shoes. In other words, as with a Type V guide, the guide tries to create an emotional impact in the user. By invoking empathy, the guide makes the user see an event in a deeper way.

Different stories about the same domain from different guides force the user to analyse and find an explanation of why different historical interpretations exist. This type of learning is an attainment target of the UK National Curiculum for History [NHC, 2006]. It has to be noted that this feature is a future goal. In the current version of the Affective Guide, the user will have the chance to interact with only one guide at any particular instance of time. Therefore, s/he gets to listen to stories from only a single perspective depending on the ideology of the guide.

Based on Dautenhahn's classification, the Affective Guide can be considered as belonging to a combination of Type II, III and IV. It selects the stories that fits the current context best by listening to the user's reponse and interpreting its meaning. It then adapts and personalises the narration based on the information gathered. Furthermore, it has a personality and possesses both semantic and emotional memories which form some kind of autobiographic memory. Thus, it is able to link the facts to its ideological standpoint within its emotional memories and presents its autobiography to the user.

5.2.1 Technical Overview

The Affective Guide System integrates an HP iPAQ hx4700 series Pocket PC[3] with a Fortuna Clip-On Bluetooth Global Positioning System Receiver[4] and Loquendo embedded text-to-speech system[5]. Due to limited resources, the Pocket PC unit cannot always carry around with it the entire information base associated with the area of attraction. Instead, a server is utilised to hold the data, perform processing and transmit the information to the hand held unit on demand. Communication between the Pocket PC and the server is through wireless connection as depicted in Figure 5.28.

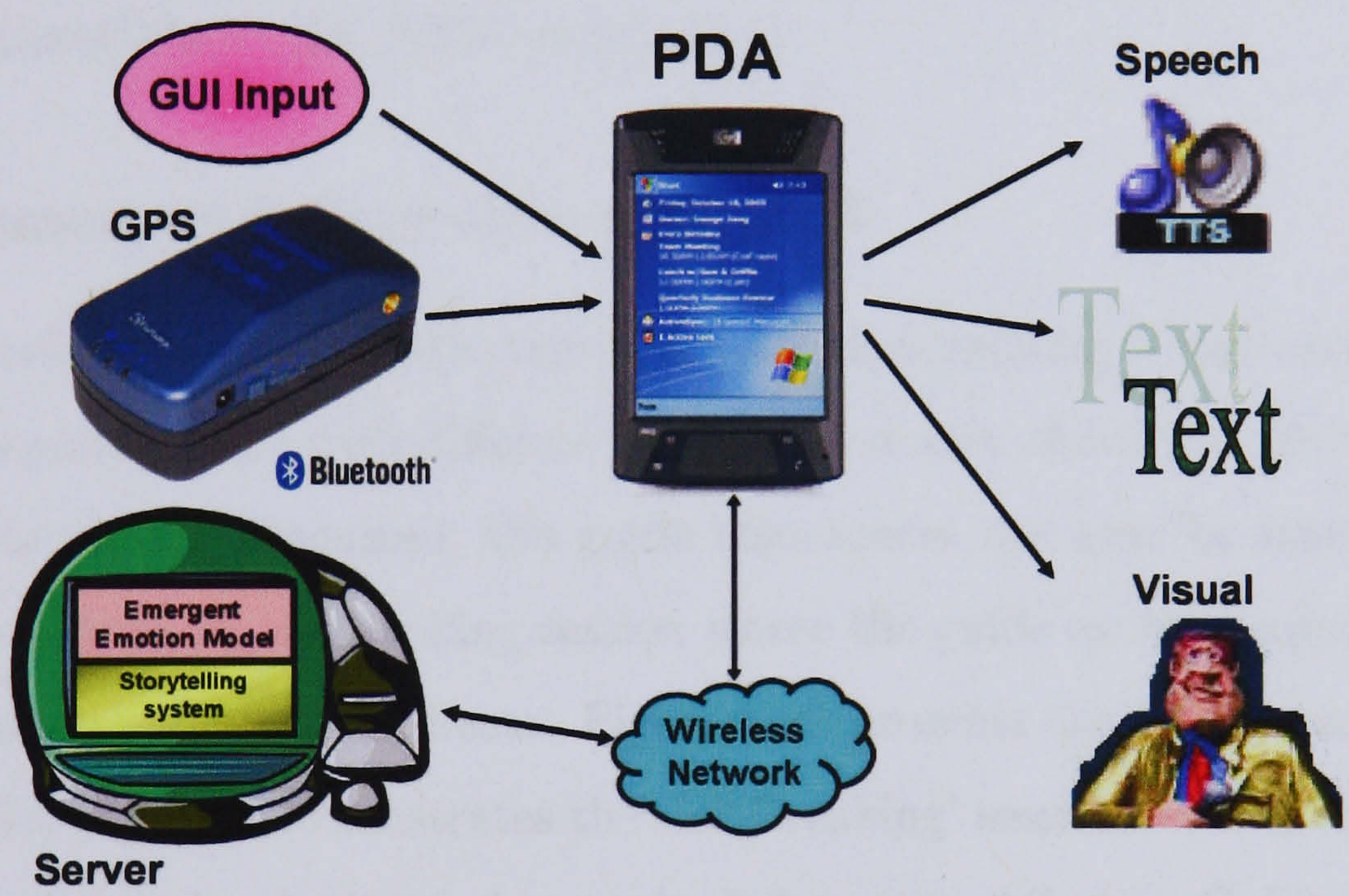


Figure 5.28: The Overall System Architecture

For the prototype version, a laptop is used as server and bluetooth communication is adopted. A crucial point for the Affective Guide is that the PDA with wireless connection can be naturally carried around without difficulty. It is also economical and the requirements threshold is significantly lower than for the systems that use see-through head-worn devices with trackers, discussed in Chapter 2.

[3]http://www.hp.com/
[4]http://www.pocketgpsworld.com/fortuna-clip-on.php
[5]http://www.loquendo.com/en/technology/tts_embedded.htm

The .NET Compact Framework 1.1 of Visual Studio.NET 2003[6] has been chosen as the development environment with Visual C#.NET as the core programming language. Design patterns[7][GoF, 2005] have been applied to ensure effectiveness and robustness of the code. A Microsoft OLE database stores the knowledge base containing the Affective Guide's memory, both current and long-term. The application accesses this data through a SQL server. Web Services manages the data exchange over the wireless network, allowing transmission of data at a higher speed and reducing network lag, a known problem with web browsers. For story generation, the system uses JESS[8] [Friedman-Hill, 2003], a Java based rule engine to perform reasoning. The IKVM.NET[9] is used to enable JESS interoperability in the .NET environment.

5.2.2 Functional Overview and GUI

In this research, there are two Affective Guides, each possessing a contrasting personality, presenting users with different versions of stories about the same events or places. As already discussed, the guide commences the tour by introducing itself. There follows an ice-breaking session where the guide extracts information about the user's name and interests. Figure 5.29 presents the 'Start' and 'End' screens, whilst Figure 5.30 illustrates the 'Ice Breaking' session screen. After the user has entered and submitted the required data, the Affective Guide chooses attractions that match the user's interests, and plans the shortest possible route to the destinations. It then informs the user of the number of attractions s/he is going to visit.

After a brief introduction to the tour, the Affective Guide navigates the user to the chosen locations by giving directional instructions, in addition to presenting the user with an animated directional arrow as shown in Figure 5.31. Further detail of the navigation system is provided in Section 5.3. On the way to the attractions, the guide draws the user's attention to other landmarks, in case the

[6]http://www.microsoft.com
[7]http://www.dofactory.com
[8]http://herzberg.ca.sandia.gov/jess/
[9]http://www.ikvm.net/

user is interested. Detection of the user's current physical position and orientation is part of what we term context-awareness. Upon arrival at a planned destination, the guide notifies the user and starts the storytelling process as described in Section 6.2 of Chapter 6. Since tourist information is location-dependent by nature, the system links electronic data to actual physical locations, thereby augmenting the real world with an additional layer of virtual information.

Figure 5.29: The 'Start' and 'End' screens

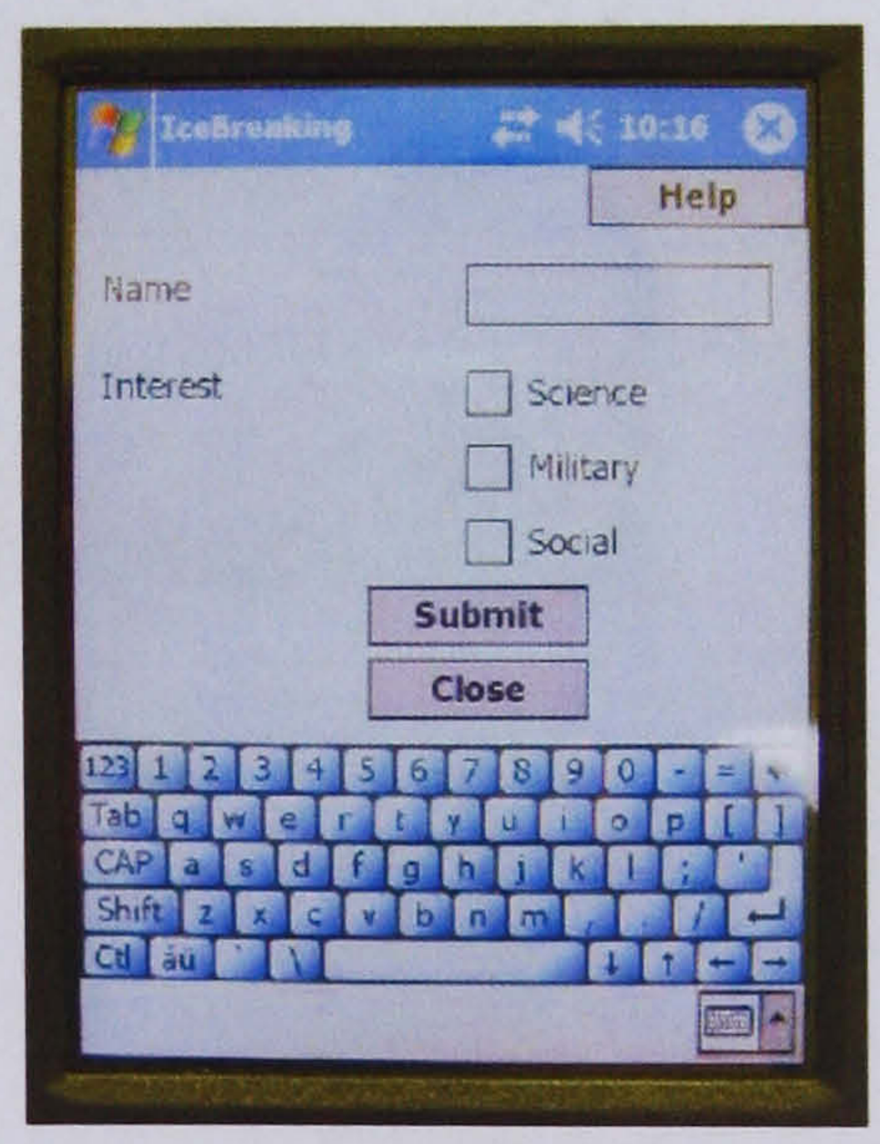


Figure 5.30: The 'Ice Breaking' session screen

A 'Head up' approach is adopted in which stories are presented using speech, allowing the user to fully appreciate the attraction visited. Figure 5.32 presents the main interaction interface during the tour session. The text is displayed on the screen allowing the user to read any information that may have been missed when listening to the speech.

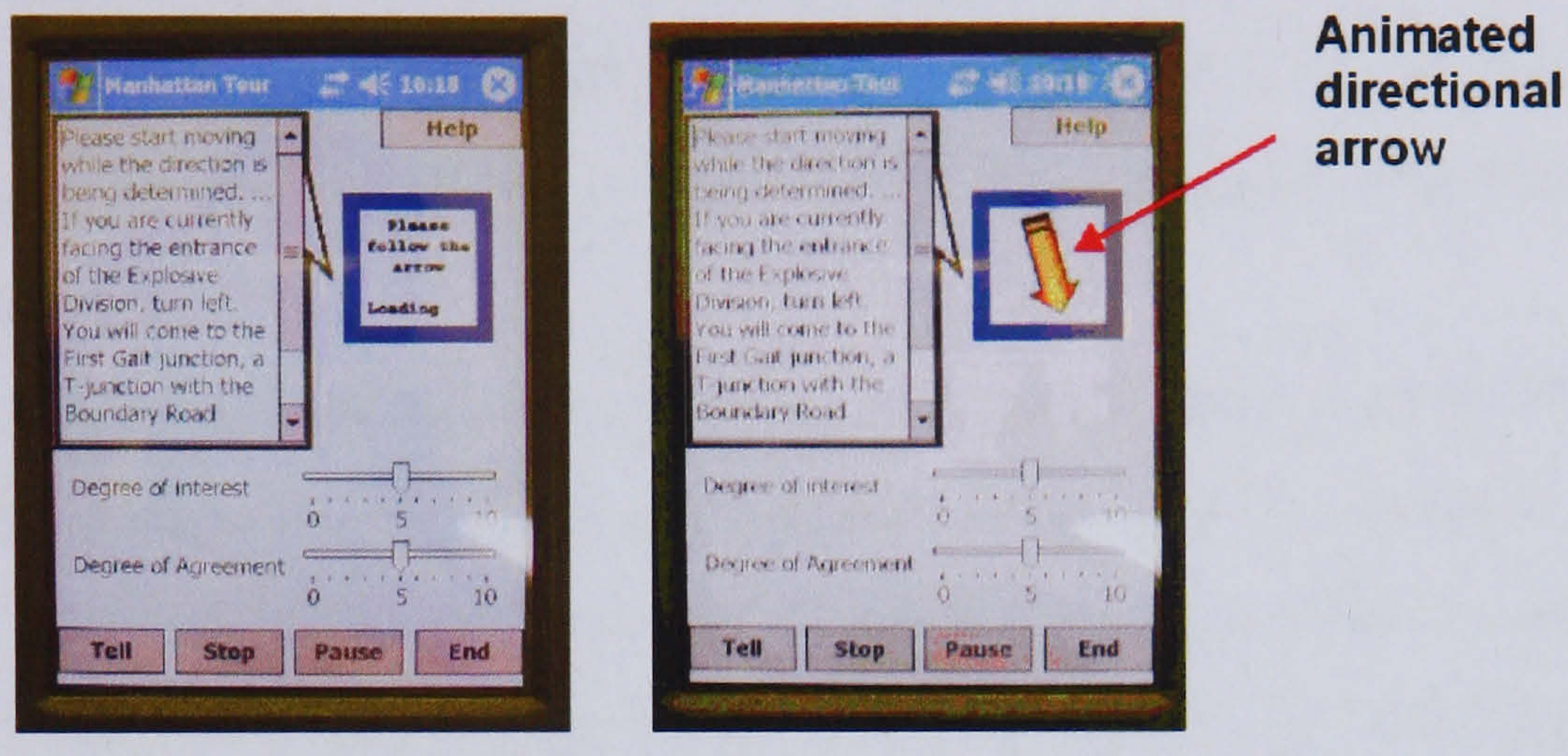


Figure 5.31: The 'Navigation' screen

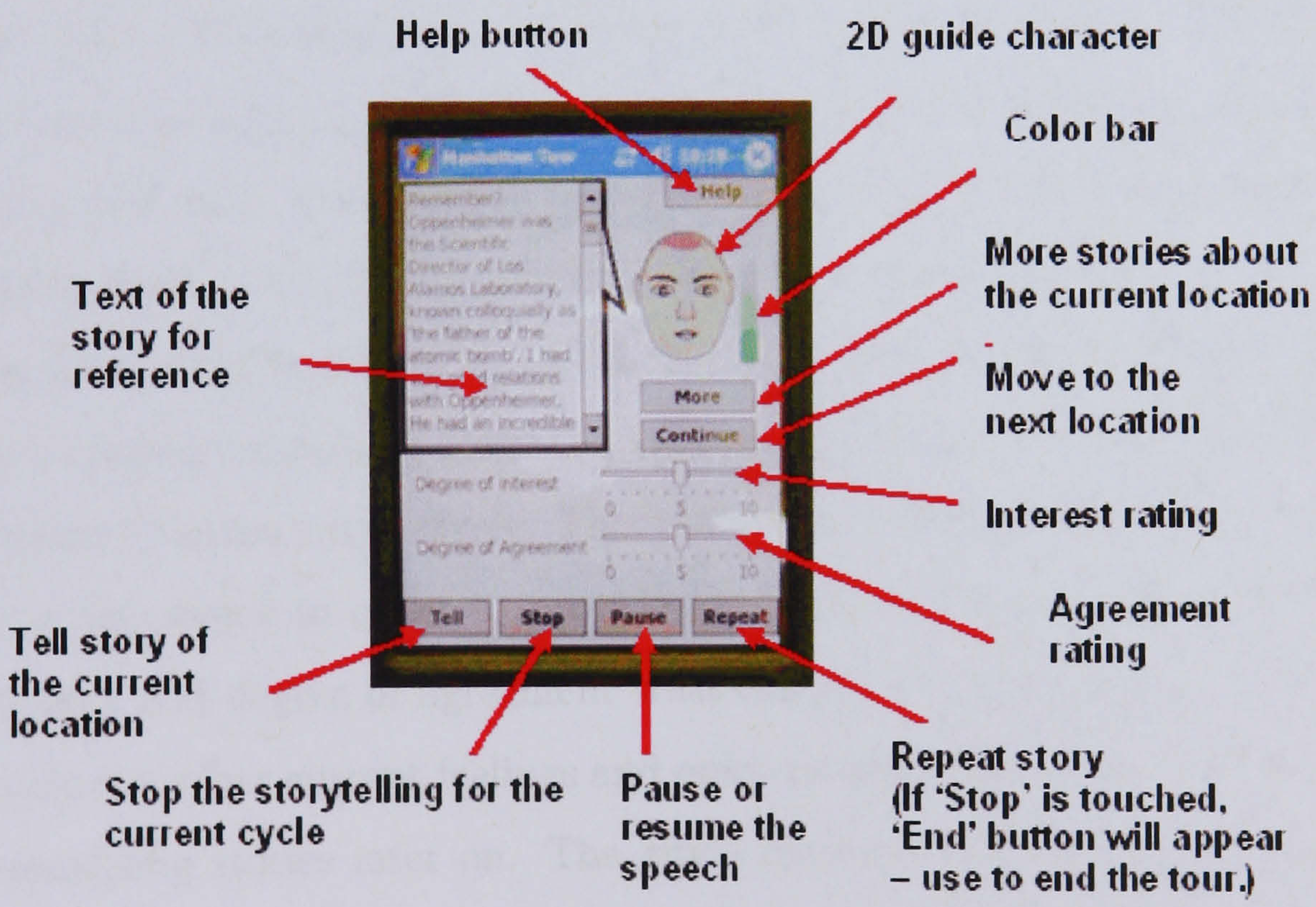


Figure 5.32: The main Graphical User Interface

In addition, we address Goren-Bar's proposal on delegation of control (refer to Section 2.3.2). There is a distribution of control between the guide and the user. Users are allowed to express their opinion about the stories presented after each storytelling cycle, and they have the freedom to stop, pause, resume or repeat the presentation whenever they wish. This makes users feel that they are in control of their experience, and that the guide cares about their feelings. On the other hand, the guide's autonomy is expressed through its ability to detect the user location, generate and present stories automatically. Moreover, it has a transparent adaptive capability, permitting it to personalise the tour based on the user's feelings.

Acknowledgement and notification using both speech and message boxes are provided periodically to reduce long idle states and ensure continuity in system behaviour. It serves as an assurance to the user that the system is operating as intended, informing them about what to expect next. On the way to the destination, if the user is attracted to a site which is not in the pre-planned route, they can activate the storytelling process manually by clicking the 'Tell' button. If information is available, the guide will start the narration, otherwise the user will be notified about the unavailability of information. This facility enables a user to wander around the attraction site and fulfill their curiosity at will during and after the planned tour. At any time, the user can always find information about the function of buttons from the 'Help' menu.

After each storytelling cycle, the user can choose to listen to more stories about the current location or move to the next location by touching the 'More' or the 'Continue' button respectively. This is the only time that the user is required to look at the screen in order to provide feedback on his/her degree of interest in the stories and degree of agreement with the guide's argument(s). The user's inputs reflect his/her current feelings and opinions about the story content, useful for personalising stories later on. The guide responds by dynamically changing its internal state, subsequently affecting its presentation style and story content. The guide is represented as a talking head that is able to express emotions and its internal states through facial animation and color manipulation, as explained in Section 6.4 of Chapter 6.

All the guide's behaviour is regulated by an emotional model, the Emergent Emotion Model. Since this is the core element of the Affective Guide, as well as of this research, Chapter 6 has been dedicated to a comprehensive description of the model, including the storytelling system and the 2-dimensional guide character. It is important that the guide not only operates correctly, but also that it does so at the right time and in the right manner, which means that the story generation and facial expressions should be in line with its emotional states. In other words, the storytelling system and the animation system must work in conjunction with the emotion model.

5.3 Navigation System

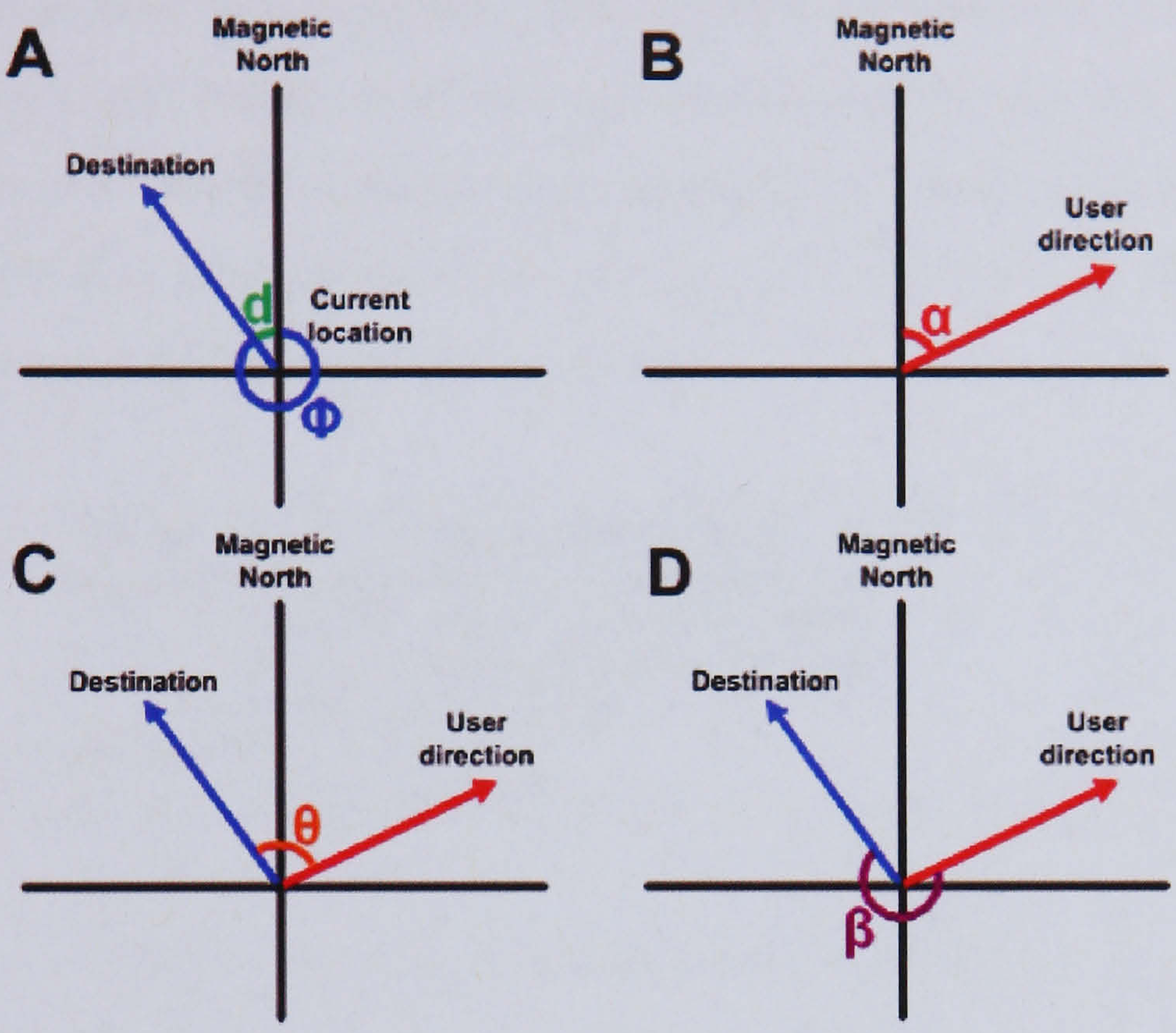
The Affective Guide is designed with outdoor attractions in mind. The user's position is determined by a Global Positioning System which provides the latitude coordinate, longitude coordinate and current movement bearing. The coordinate range of each location has been pre-recorded and once the user is within a particular range, the name of the attraction is mapped onto the physical location [Pan, 2005]. The GPS readings are continuously updated as the user locomotes.

5.3.1 Orientation

The user's orientation is calculated based on previous and current location information, which means that the user needs to be moving before the orientation can be determined. In order to guide the user in the right direction, the steps in Figure 5.33 are performed. The figure also shows all the related angles involved in the calculation. Hence, the system adapts to users' behaviour, facilitating their movement within the space by aiding orientation.

5.3.2 Route Planner

A route planner has been developed to direct the user's navigation, and to propose suggestions about the best route to follow. The planner selects the attractions, generates the next stop based on the current location and replans the route when the user strays from the planned path. In order to speed up performance and



- Acquire the coordinates of the destination node, *destLatitude* and *destLongitude*
- Acquire the coordinates of the user's current location, *currentLatitude* and *currentLongitude*
- Calculate the bearing, Φ, from the current location to the destination node relative to the magnetic north, (Figure A)

$$\begin{aligned} latitude &= destLatitude - currentLatitude \\ longtitude &= destLongitude - currentLongitude \\ a &= \cos(currentLatitude)\sin(destLatitude) - \\ &\quad \sin(currentLatitude)\cos(destLatitude)\cos(longitude) \\ b &= \sin(longitude)\cos(destLatitude) \\ y &= \arctan(b / a) \\ \Phi &= (y \bmod 2\pi)(180 / \pi) \end{aligned}$$

- Calculate the displacement, d, of Φ to the magnetic north, (Figure A)

$$d = 360 - \Phi$$

- Ascertain the current user's movement bearing, *userBearing*, α, (Figure B)
- Calculate the direction to the destination, β, relative to the user current movement direction, (Figure D)

$$\theta = \alpha + d$$
$$\beta = (360 - \theta) \bmod 360$$

Figure 5.33: Direction Computation Algorithm

ensure sufficient resources during the tour session, the route planner is supplied with all the available attractions and the associated latitude and longitude coordinates before the tour. With this information, the system calculates the distance for every possible pair of attractions. Taking the coordinates of the first node as *coord1Latitude* and *coord1Longitude*; and coordinates for the second node as *coord2Latitude* and *coord2Longitude*, the equations in Figure 5.34 are applied. In the equation, R is the earth's mean radius in metres. Thus, all the resulting distances between the node pairs are in metres.

$$
\begin{aligned}
latitude &= coord2Latitude - coord1Latitude \\
longitude &= coord2Longitude - coord1Longitude \\
a &= \sin(latitude/2)^2 + \cos(coord1Latitude) \\
&\quad \cos(coord2Latitude)\sin(longitude/2)^2 \\
c &= 2\arctan(\sqrt{a} / \sqrt{(1-a)}) \\
distance &= Rc \\
&\quad \text{where } R = 6371000
\end{aligned}
$$

Figure 5.34: Distance Calculation Algorithm

The route planner also receives a file that lists all the neighbouring nodes. The system then generates all the possible paths from one attraction to another using rule inference. This task is performed by JESS[10]. Taking the source node as S; the destination node as D; each node in a single neighbouring *NODEPAIRS* as *N1* and *N2*; and the resulting path as P, the following rules are applied to generate the source-destination paths.

```
For each pair = (N1, N2) ∈ NODEPAIRS
  If N1 = S
        If N2 ≠ D and N2 ≠ N1 and N2 ∉ P
              Add N2 to P

        If N2 = D and N2 ≠ N1 and N2 ∉ P
          Store P into pathlists
```

The total distance from each source node to the destination node is also determined when the path is generated. After all possible paths for every possible

[10]http://herzberg.ca.sandia.gov/jess/

attraction pair are obtained, the system performs a comparison so that the shortest path between pairs is selected and stored in the guide's memory database. Thus, during the tour session, the guide only needs to query the database for the shortest path by supplying the user's current location and the intended destination. This pre-generated path will provide the guide with the next intermediate node that takes the user nearer to the destination.

5.4 Summary

This chapter presented our findings on a survey of tour guides of which we have classified the information gathered into five types of guides. The Affective Guide is a mobile virtual guide that combines attributes of Type I, Type II and Type V guides. It possesses both emotions and a personality that affect its behaviour and processing strategy. The architecture of the Affective Guide was described. A description of the system was provided covering the technical elements, functionality and graphical user interface as well as the navigation system. The core element of the system, the Emergent Emotion Model, is presented in Chapter 6.

Chapter 6

Emergent Emotion Model

I can't change the direction of the wind, but I can adjust my sails to always reach my destination.
- *Jimmy Dean*

If we begin with certainties, we shall end in doubts; but if we begin with doubts, and are patient in them, we shall end in certainties
- *Francis Bacon. English philosopher, 1561–1626*

Intelligence is not to make no mistakes, but quickly to see how to make them good.
- *Bertolt Brecht. German poet and playwright, 1898-1956*

This chapter describes our Emergent Emotion Model, the core component of the Affective Guide, allowing creation of intelligent guides with attitude. Instead of capturing the user's emotion, the Affective Guide takes the opposite approach of presenting the emotion of an intelligent agent as a tactic to attract the user's attention and improve interaction. We start with the global architecture of the emotion model, then proceed to the description of each of the internal components of the model. The explanation covers the emotional component, the storytelling system and the 2-dimensional guide character. The algorithms involved in each of these subcomponents are documented. We also include concrete examples of the application of the model in the Affective Guide.

6.1 Global Architecture

The Emergent Emotion Model is the novel element of this research. It is based on the 'Psi' model presented in Chapter 3. This model is biologically inspired where the interest lies in modelling the conditions for the emergence of emotions, avoiding rigidity in behaviour and providing more variation in the resulting emotions. Taking the 'Psi' model as a basis, we have added a storytelling system and emotional memories. We put more emphasis on social interaction with humans and maintenance of cognitive needs, whereas Dorner's stimulations are more concerned with 'survival' related issues.

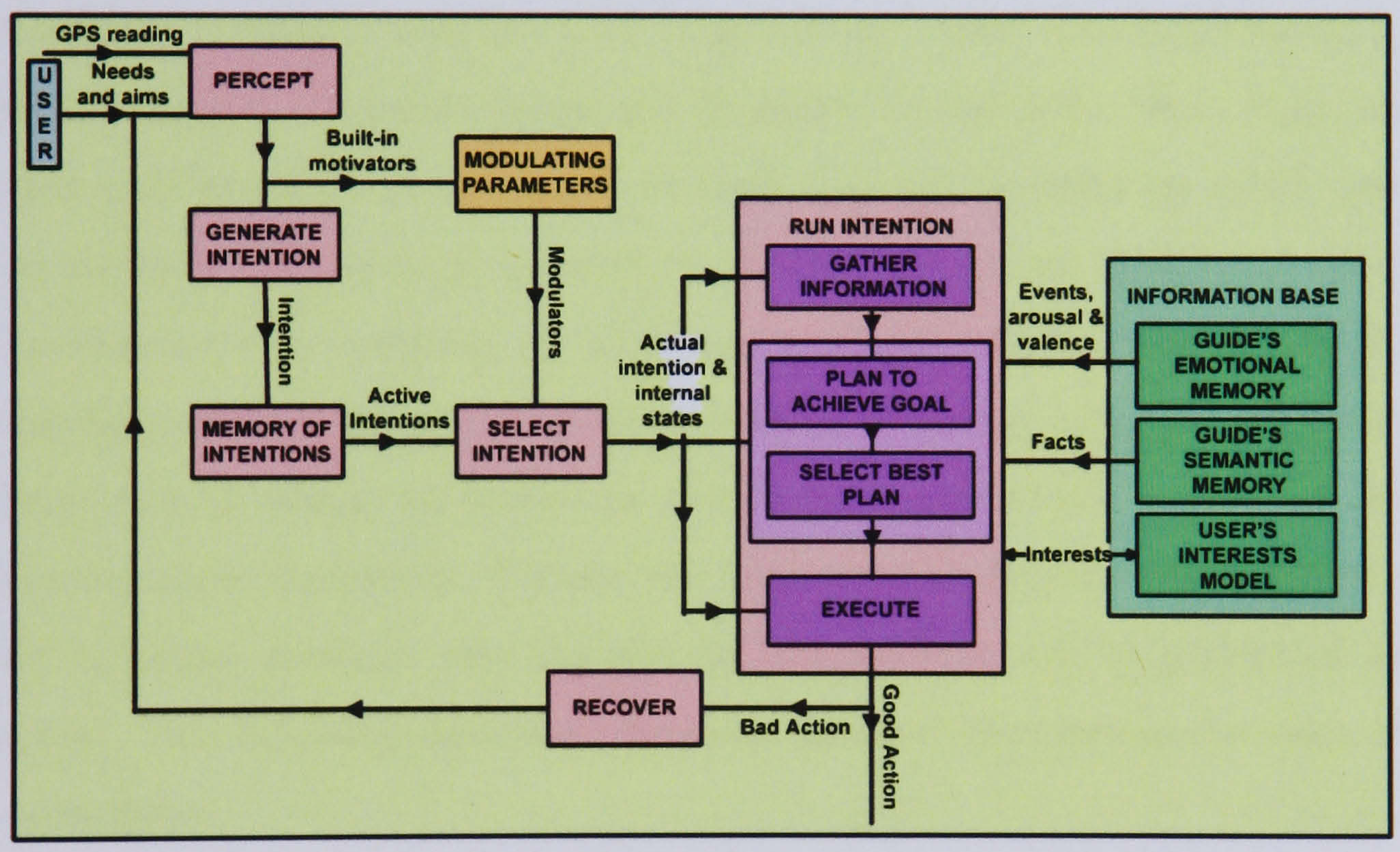


Figure 6.35: The Emergent Emotion Model

In our architecture, motivation is represented by the needs of the guide to maintain its performance and establish an acceptable condition for interaction with the user. It takes into consideration the user's feelings throughout the interaction so that appropriate responses can be given. Emotions are emergently determined by the modulating parameters, whilst cognition is represented by the information processes in PERCEPT, GENERATE INTENTION, SELECT

INTENTION, RUN INTENTION, RECOVER as well as in the memory of intentions represented by the purple boxes in Figure 6.35. When the interaction between the user and the guide starts, the guide's long term memories, both semantic and emotional, contain a complete set of location-related information and the guide's past experiences. In contrast, the user interests model is empty. The guide makes assumptions about the user's interests based on the initial information extracted through the ice-breaking session.

Functionally, the guide perceives the environment continuously. It reads the user's inputs which include the user's degree of interest in the stories (DoI) and the user's degree of agreement to the guide's arguments (DoA); the system feedback, either success or failure; and the GPS information. Using this information, it updates its built-in motivator values and generates intention(s). More than one intention can be active at any point of time, and the decision on which and how to perform the intention is based on the guide's current emotional state. The parameters that influence its emotional state are the built-in motivators and modulators such as *arousal level, resolution level* and *selection threshold.* By doing this, it adapts its behaviour according to its internal states and the environmental circumstances. Finally, the execution of intention will produce a success or failure feedback into the system and recovery will be performed as necessary. The following discussion provides detailed descriptions for each of these processes.

6.1.1 Built-in Motivators

In our context, the guide has two built-in motivators to maintain; *competence* and *certainty.* The *level of competence* refers to the guide's ability to cope with the user's differing perspective about an issue or event whereas the *level of certainty* is the degree of predictability of the environment and of the user interests. For example, if the user disagrees with the guide's opinion, its *level of competence* decreases. Furthermore, if the user finds the stories uninteresting, the guide's *level of certainty* decreases, as its prediction about the user's interests is incorrect.

Figure 6.36 illustrates the interaction between the environment variables and the built-in motivators in the PERCEPT process.

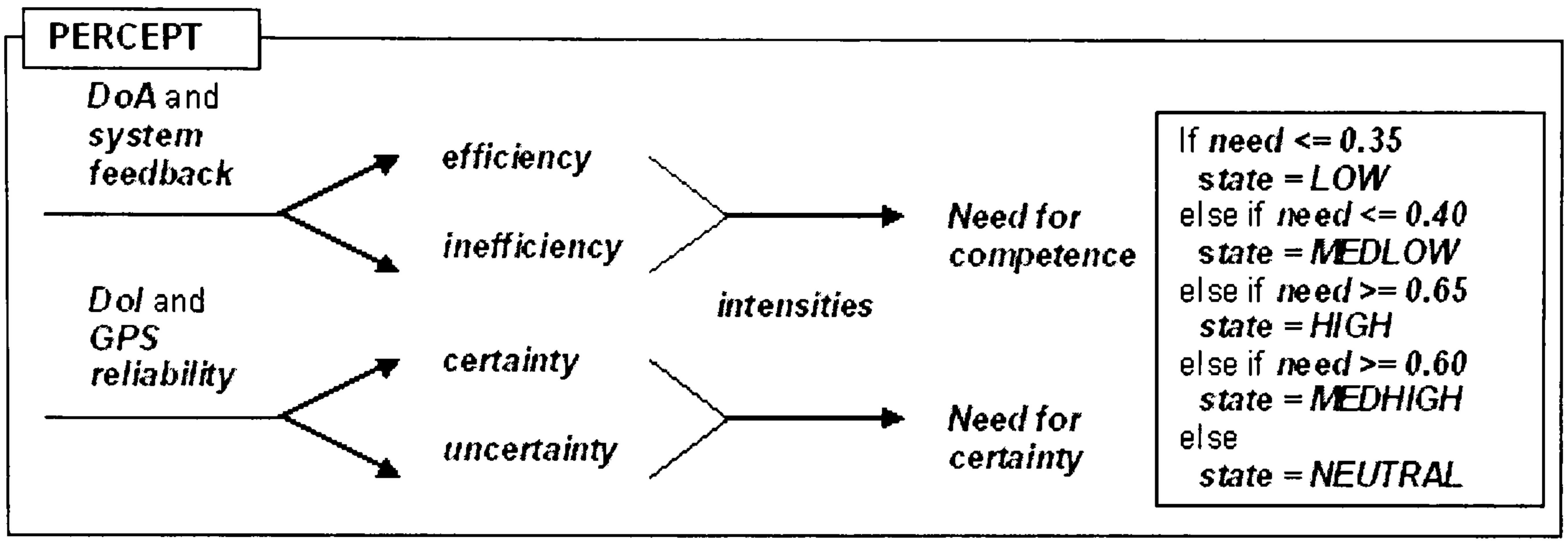


Figure 6.36: Interaction between stimuli and the built-in motivators

From the diagram, it can be seen that two signals - positive and negative exist for each built-in motivator: *efficiency* versus *inefficiency* for *competence* and *certainty* versus *uncertainty* for *certainty.* Additionally, each built-in motivator has *intensity* and *need* values. Every time a new input is received, all the attributes of each built-in motivator will be updated. The intensity of the positive and negative signals are calculated as shown in Equation 6.1 and 6.2 respectively. In the equations, *pSignal* represents the positive signal while *nSignal* represents the negative signal. *pSWeight* and *nSWeight* are the weights of the positive and negative signals respectively. f denotes the environment variable values, which include the GPS reliability, DoI, DoA and the system's own feedback. *iWeight* refers to the degree of impact a particular variable has on the motivator. In the current version, both GPS reliability and DoI influence *certainty* but in the ratio of 1:3, which means the DoI has a higher impact on the motivator than the GPS accuracy. This is because the feelings of user are viewed as more important. The same ratio applies for success or failure and DoA in the case of *competence.*

$$pSignal = pSignal + (pSWeight)(f)(iWeight) \tag{6.1}$$

$$nSignal = nSignal + (nSWeight)(1 - f)(iWeight) \tag{6.2}$$

Using the values of the opposing signals, the *intensity* of the respective motivators is generated using Equation 6.3. This intensity value is maintained across each cycle to ensure a gradual change in the guide's internal state. Subsequently, calculations of *needs* are performed using Equation 6.4. The *need* ranges from 0 to 1 and measures deviation from the set point indicator, referring to the *need for competence* and the *need for certainty.* A *need* will tend to increase in intensity unless it is satisfied. The guide's aim is to keep these values as low as possible. The *need* values will affect the modulator values, discussed in the next section. For example, a high *need for competence* or a high *need for certainty* will increase the arousal level and a low *need for competence* or a low *need for certainty* will decrease the arousal level.

$$\begin{aligned} intensity &= Max(0, Min(1.7, intensity + pSignal - nSignal)) && (6.3) \\ need &= 1 - (Log(1 + intensity)) && (6.4) \end{aligned}$$

The *need* values also determine the *state* of the motivators, used for intention selection, discussed in Section 6.1.3. Each built-in motivator can be in one of the following five *states* at any time instant: LOW, MEDLOW (medium low), NEUTRAL, MEDHIGH (medium high) and HIGH with value 0.35 as the lower limit, 0.40 as the medium lower limit, 0.60 as the medium upper limit and 0.65 as the upper limit. To elaborate, if the *need* value of the built-in motivator falls below 0.35 (inclusive), then its state is LOW; if the *need* value falls between 0.35 (exclusive) and 0.40 (inclusive), then the motivator's state is MEDLOW. On the opposite side of the scale, if the *need* value is greater than 0.65 (inclusive), then the motivator's state is HIGH; if the *need* value falls between 0.60 (inclusive) and 0.65 (exclusive), then the motivator's state is MEDHIGH. Any value between 0.40 and 0.60 exclusive will result in a NEUTRAL state.

6.1.2 Modulators

The guide has three modulating parameters of its emotional state: *arousal level, resolution level* and *selection threshold.* Like the motivators, these modulators have an *intensity* that falls in the range of 0 and 1 inclusive and a *weight,* a constant value that will shape the guide's personality, discussed in Section 6.1.6. The influence of the built-in motivators on the *arousal level* that further influences other modulators is presented in Figure 6.37.

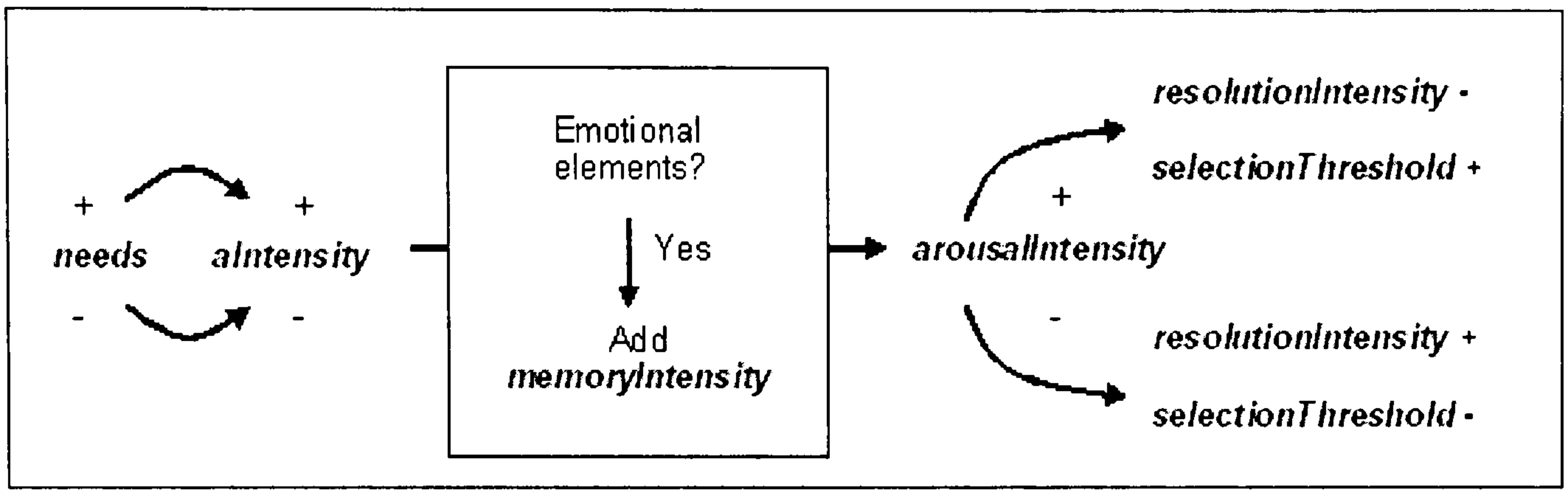


Figure 6.37: Interaction between the built-in motivators and the modulators

Arousal level refers to the speed of processing, that is, the guide's readiness to act. The higher the *arousal level*, the more pressing it is for the guide to react to the situation at hand, hence fast decisions and actions are sought. Thus, a high arousal tends to narrow attention and inhibit in-depth planning. The calculation of current arousal intensity (*aIntensity*) is given by Equation 6.5. In the equation, *sumOfNeed* is the total value of *need for competence* plus *need for certainty.*

$$aIntensity = Log(1 + sumOfNeed)(weight) \tag{6.5}$$

In addition to *intensity* and *weight*, arousal has an additional attribute called *memoryIntensity*, an arousal value retrieved from emotional memory (please refer to Section 6.1.5). After the story generation process, if emotional story element(s) have been included, a final *arousalIntensity* that combines both current and memory arousal is calculated using Equation 6.6. It is assumed that the arousal strength of current experience is stronger compared to the retrieved emotional event, thus a weight of 0.4 is applied to the value from memory while a weight of 0.6 is applied to the current arousal value. This assumption is made based on the fact that the guide is directly involved in the currently happening event, hence experiencing a more intense feedback from this event than the event it recalls from memory. If no emotional element has been included in the story, the final *arousalIntensity* takes the value of the current *aIntensity*.

$$arousalIntensity = 0.4(memoryIntensity) + 0.6(aIntensity) \tag{6.6}$$

Arousal affects both the *resolution level* and the *selection threshold* values. *Resolution level* covary inversely while *selection threshold* covary directly to the *arousal level*. *Resolution level* determines the carefulness and attentiveness of the guide's behaviour. When the *resolution level* of the guide is high, it performs more extensive memory retrieval and story generation, thus, presenting longer stories. A low *resolution level*, on the other hand, will lead the guide to provide only brief facts about a particular location. The calculation of *resolution level* is shown in Equation 6.7.

$$resolutionIntensity = (1 - arousal^2)(weight) \tag{6.7}$$

$$selectionThreshold = (arousal^2)(weight) \tag{6.8}$$

Lastly, *selection threshold* is the limit competing motives have to cross in order to become active. The higher the *selection threshold*, the more difficult it is for another motive to take over and be executed. This modulator prevents oscillations or dithering between intentions. Its value is obtained using Equation 6.8. Both *resolution level* and *selection threshold* are distinguished from *arousal level* so that the influence of *weight* parameters in Equation 6.7 and Equation 6.8 can be brought to bear. These parameters determine the personality of the guide as discussed in Section 6.1.6. Once the personality of the guide has been assigned, *arousal level* will drive the *resolution level* and the *selection threshold* values.

6.1.3 Generate and Select Intention

In short, the guide has three possible intentions: UPDATEBELIEF (update its belief about the user's interests), NEWTOPIC (adjust the stories presentation) and STORYTELLING (perform storytelling). Each intention becomes active in a different interaction situation. In every interaction cycle, two intentions are generated based on *needs* defined by the built-in motivators and *strength*, which takes account of the intention tendencies (likelihood to perform the intention), its previous experience and expectation of success. The *strength* of each intention is a measure of its relevance to the current situation. The resulting intentions can be similar to or differ from each other. The intention based on *needs* is called *currentIntention* while the intention based on *strength* is called *leadingIntention.* The pseudocode for generation of these intentions is presented in Figure 6.38.

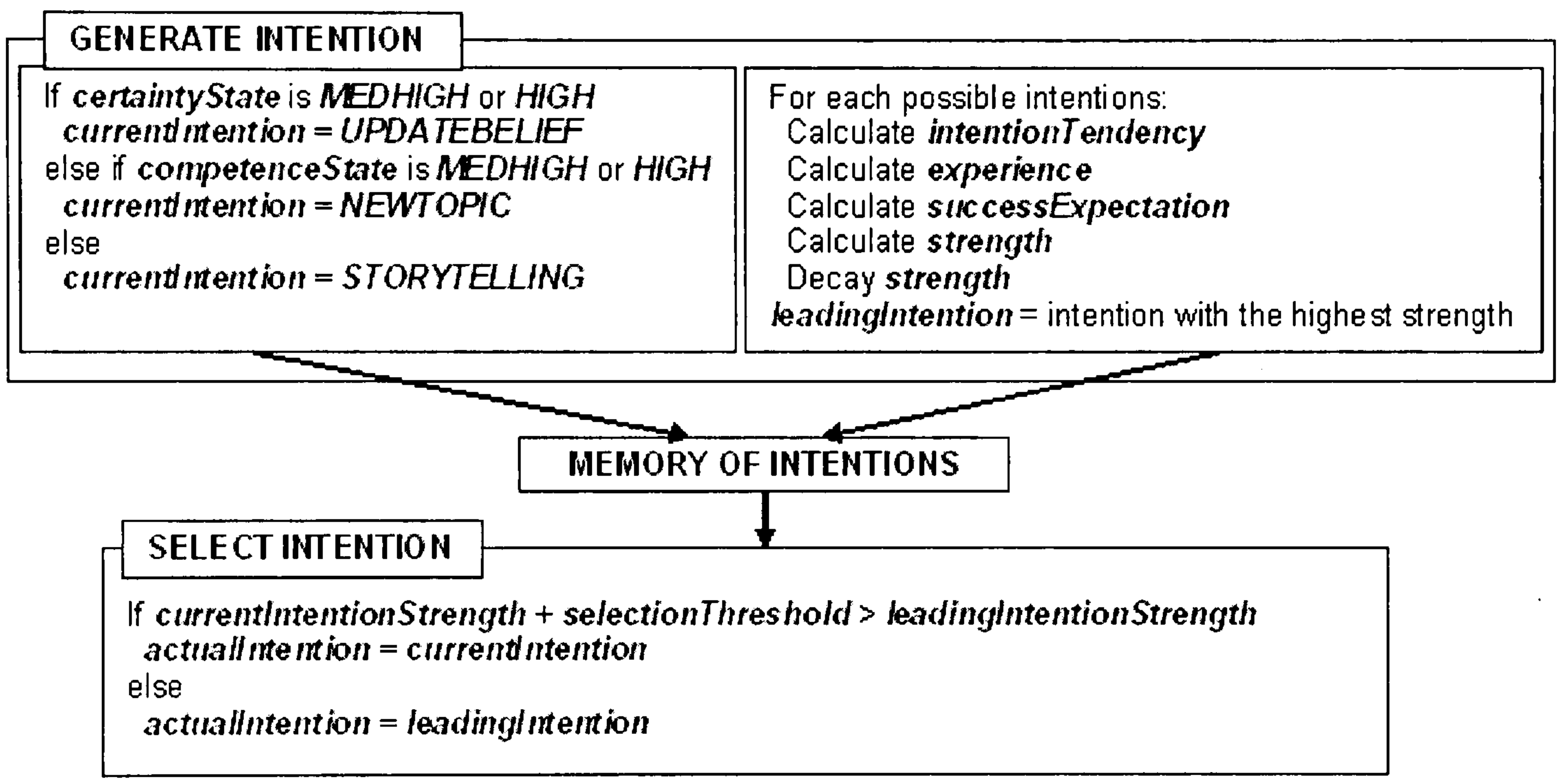


Figure 6.38: Intentions generation and selection

The *leadingIntention* is determined based on the principle of expectancy-value where the intention with the highest strength is selected. It is obtained by applying Equation 6.9 to Equation 6.16 in sequential order. The calculation in Equation 6.12, 6.13, 6.14, 6.15 and 6.16 are applied once to each of the possible intentions. It has to be noted that the choice of parameters in the equations was for purely empirical reasons.

$$storytellingTendency = (1 - needForCertainty)(1 - needForCompetence) \tag{6.9}$$

$$newTopicTendency = needForCompetence^2 \tag{6.10}$$

$$updateBeliefTendency = needForCertainty(1 - needForCompetence) \tag{6.11}$$

$$
\begin{aligned}
experience &= \frac{successCount}{totalPerformance} && (6.12)\\
successExpectation &= experience + \frac{levelOfCompetence}{2} && (6.13)\\
strength &= (successExpectation)(tendency) && (6.14)\\
finalStrength &= (finalStrength)(intentionFactor) && (6.15)\\
intentionFactor &= intentionFactor + 0.05 && (6.16)
\end{aligned}
$$

storytellingTendency is the guide's likelihood to perform storytelling, *newTopicTendency* is the guide's likelihood to perform story adjustment while *updateBeliefTendency* refers to the guide's likelihood to update its belief about the user's interests. *experience* represents the ability of the guide in performing an intention which is affected by *successCount*, the number of successes so far in performing the respective intention divided by *totalPerformance*, the total number of times the intention was performed. *successExpectation* is the probability of success for an intention and *tendency* represents *storyTendency, newTopicTendency* or *updateBeliefTendency.* Lastly, *finalStrength* is the strength of the intention after application of decay through multiplication by *intentionFactor.*

Both active intentions are stored in a memory of intentions. Since more than one intention can be active at the same time, the guide selects one of them depending on the importance of the *needs* and the *selection threshold* value. The *leadingIntention* will overtake the *currentIntention* if and only if its strength is greater than the strength of the *currentIntention* plus *selection threshold.* The selected intention then becomes the actual intention to be executed.

When either UPDATEBELIEF or NEWTOPIC becomes active, a decay is applied to the intention in order to stabilise the guide. It decreases the probability of the same intention being chosen again for a short while, avoiding continuous change of beliefs or adjustment of topics. This is achieved by assigning a low *intentionFactor* to the intention. In each iteration, the *finalStrength* of each intention is obtained by multiplying the generated *strength* with the *intentionFactor* as shown in Equation 6.15. Hence, a low *intentionFactor* will produce a low intention strength. This factor is increased after the *finalStrength* is calculated and in subsequent iterations until it reaches a maximum value 1.0.

6.1.4 Run Intention

In order to execute an intention, the guide decides whether to explore for more information, to design a plan using the available information or to run an existing plan, depending on which intention is selected and its emotional state. Prompt response occurs when there is no story to tell or story for the current location has finished at which point the guide informs the user of the unavailability of any story. Planning is performed for STORYTELLING. In the case of UPDATEBELIEF and NEWTOPIC, the guide will explore the database for information so that appropriate changes to its belief and story topic may take place. Further detail on intention execution is presented in Section 6.3.1 after the storytelling process is discussed.

6.1.5 Emotional Memory

> *You can't have a sustained feeling without the activation of arousal systems. You can't have a sustained emotional experience without feedback from the body or without at least long-term memories that allow the creation of "as-if" feedback. But even "as-if" feedback has to be taught by real-life feedback. The body is crucial to an emotional experience either because it provides sensations that make an emotion feel a certain way right now or because it once provided the sensations that created memories of what specific emotions felt like in the past.*
> \- *LeDoux*

Supporting the above view and reinforcing our argument in Chapter 3, we argue that an emotional memory is important and necessary for the Affective Guide. Since a life story is always more interesting than simply bare facts, the emotional recollection of past experiences will allow the guide to tell more believable and interesting stories. The user will be 'Walking Through Time' as the guide takes them through the site presenting its life experiences and reflecting the emotional impact of each experience.

Holding to this view, the Affective Guide possesses a long-term memory that is made up of declarative memories, both semantic and emotional. Additionally, the guide's current memory holds information relating to recent processing. Semantic memory is a memory for facts, including location-related information and the user's profile, while emotional memory is memory for experienced events and episodes. The guide's emotional memories are generated through simulation of past experiences. Consistent with Kensinger and Corkin [2004]'s proposal, the guide's emotional memory holds not only information about when, what and how an event happened, but also an 'arousal' tag and a 'valence' tag. The inclusion of the 'arousal' tag is analogous to the *Emotional Tagging* concept [Richter-Levin and Akirav, 2003]. 'Valence' denotes how favorable or unfavorable an event was to the guide.

When interacting with the user, the guide is engaged in meaningful reconstruction of its own past [Dautenhahn, 1998b], at the same time presenting facts about the site of attraction. This recollective experience is related to the evocation of previously experienced emotions through the activation of the emotion tags. These values combine with the built-in motivators values to trigger the *arousal level*, resulting in re-experiencing of emotions, though there might be a slight variation due to the input from the user, which provides positive or negative stimuli to the guide.

$$\begin{aligned} currentValence &= ((1 - (needForCompetence + needForCertainty)/2) \\ &\quad + experience)/2 \qquad (6.17) \\ valence &= 0.6(currentValence) + 0.4(memoryValence) \qquad (6.18) \end{aligned}$$

The memory arousal is combined with the guide's current arousal as explained in Section 6.1.2. On the other hand, the valence value will be combined with the guide's current valence which is computed based on *need for certainty*, *need for competence* and *experience* in performing the current intention, as depicted in Equation 6.17. For calculation of the final *valence*, shown in Equation 6.18, it is again assumed that current experience has greater emotional impact than the retrieved experience. Therefore, consistent with the arousal calculation, the weight for the valence value from memory to that for the current valence value is in the ratio of 2:3. The final value will fall in the range 0 to 1 where a value less than 0.5 is viewed as a negative valence while a value of more than 0.5 is considered as a positive valence.

6.1.6 Personality

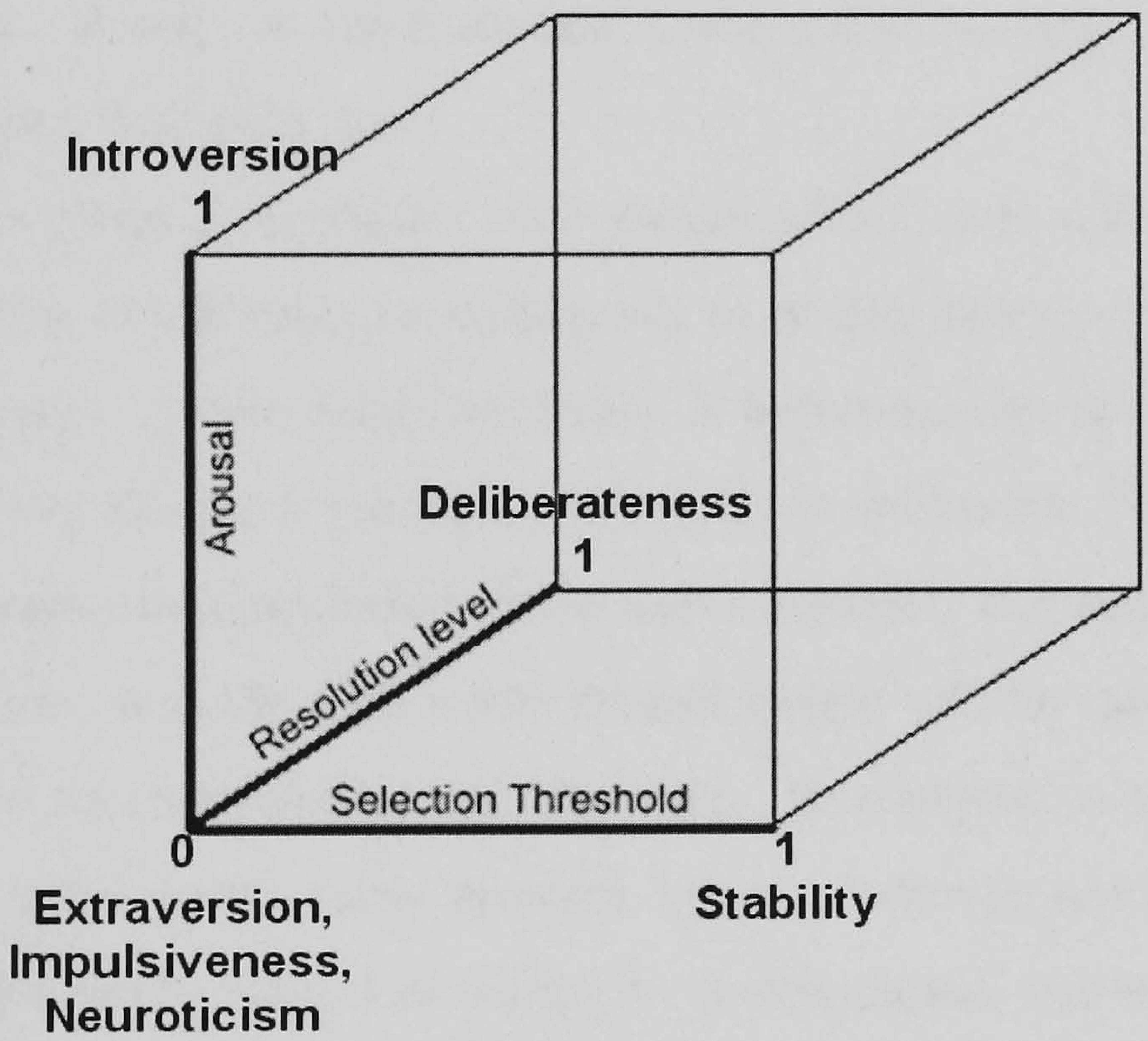


Figure 6.39: Personality cube

In addition to emotion, personality also emerges from varying the weight of each modulator, which we mapped onto a personality traits model. Similarly to emotion, personality is not defined explicitly but results from the overall activity of the guide and its patterns of interaction. It is expressed by the way the guide tackles interaction circumstances. Figure 6.39 gives an illustration of how variation in the modulators' weights can lead to guides with different personalities. The modulators are mapped onto the temperament dimensions defined by Eysenck and Eysenck [1985], except that 'Psychoticism' is replaced by the

Impulsivity-Deliberateness dimensions of Buss and Plomin [1975] which better describe the *resolution level.* The *arousal level* corresponds to the Extraversion-Introversion dimension while the *selection threshold* represents the Neuroticism-Stability dimension.

If a guide has a *selection threshold* weight of 0.1, this will mean that it is almost impossible for the guide to achieve a goal as it is very easy for another motive to become active. The guide will be neurotic, as it continuously changes its goal, most of the time without actually carrying out the plan to achieve it. As the weight increases, it becomes more and more difficult for competing motives to exert control. When the value reaches 1, the guide is stable and will always hold to its current dominant goal.

If a guide is given a *resolution level* weight of 0.1, this will mean that the guide is impulsive. It will react spontaneously or present the story briefly without much consideration. As the weight increases, it becomes more and more attentive and careful. When the value reaches 1, the guide is deliberate, performs detailed planning and presents stories based on the user's interest. The same applies to the arousal dimension. A guide with a low arousal weight will be calm, or extrovert, willing to share its experiences with the user. In contrast, a guide with high arousal weight will be very easily aroused, hence producing quick reactions and brief stories most of the time, less willing to communicate, and so, introverted.

Hence, by changing the *weight* parameters in Equation 6.5, 6.7 and 6.8 (Section 6.1.2), different personality guides can be produced. According Nass et al. [1995], in human-computer interaction, people prefer computer agents that aligns to them and they tend to rate these agents as more helpful and more intelligent. This implies that by assigning the Affective Guide with a personality that conforms to the user's personality, an improved interaction experience may be achieved in the user.

6.2 Storytelling System

Storytelling capabilities are a vital aspect of a tour guide. To achieve interesting stories, we move away from a tour guide that recites facts to a guide that tells stories by improvising.

6.2.1 Narrative Constructor

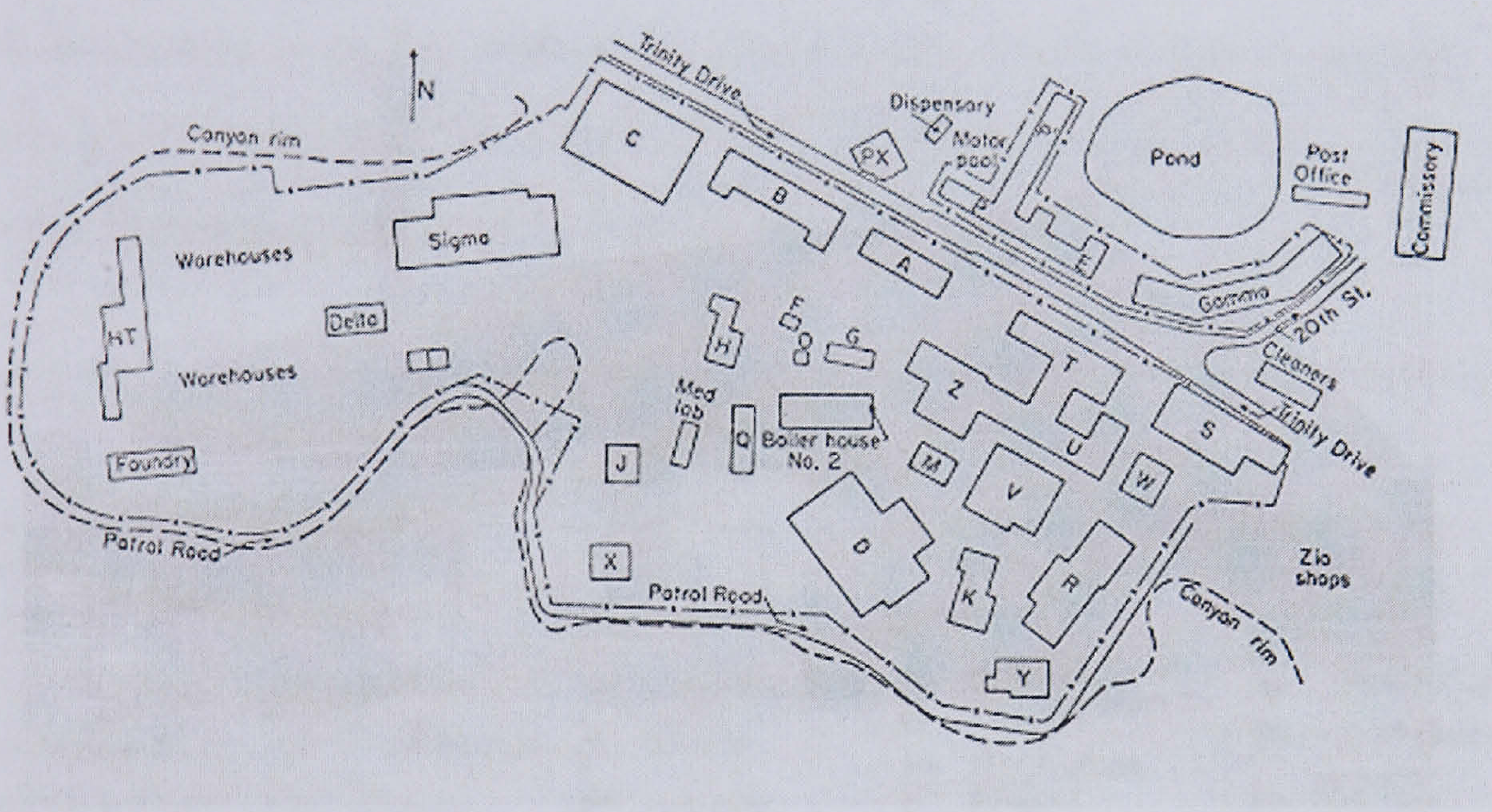


Figure 6.40: Los Alamos Technical Area (from [Association, 2006])

In the prototype version of the Affective Guide, the 'Los Alamos' site of the Manhattan Project[1] has been choosen as the narrative domain. The Manhattan Project was chosen because it contained many characters with different personalities and ideologies that can be used as Affective Guides. The buildings in the 'Los Alamos' technical area (Figure 6.40) are mapped onto the Heriot-Watt Edinburgh campus buildings. Hence, all stories are related to the 'Making of the atomic bomb' [Rhodes, 1986].

[1] http://www.lanl.gov/

Ontologies and Entities

As in Ibanez's system discussed in Section 2.6, the Affective Guide defines two informal ontologies. First, a story element attributes ontology, which consists of the attributes used to annotate the story elements. These attributes and their corresponding interest areas - *General, Science, Military, Politics* and *Social* are hierarchically structured. Figure 6.41 shows the attributes ontology for the prototype version. Second, the guide profile ontology describes the guide's role and interests. In the current version, two guides are implemented, a scientist who is interested in topics related to *Science* and *Politics*, and a member of the military who is interested in topics related to *Military* and *Politics.* Both guides also have *General* knowledge about the attractions.

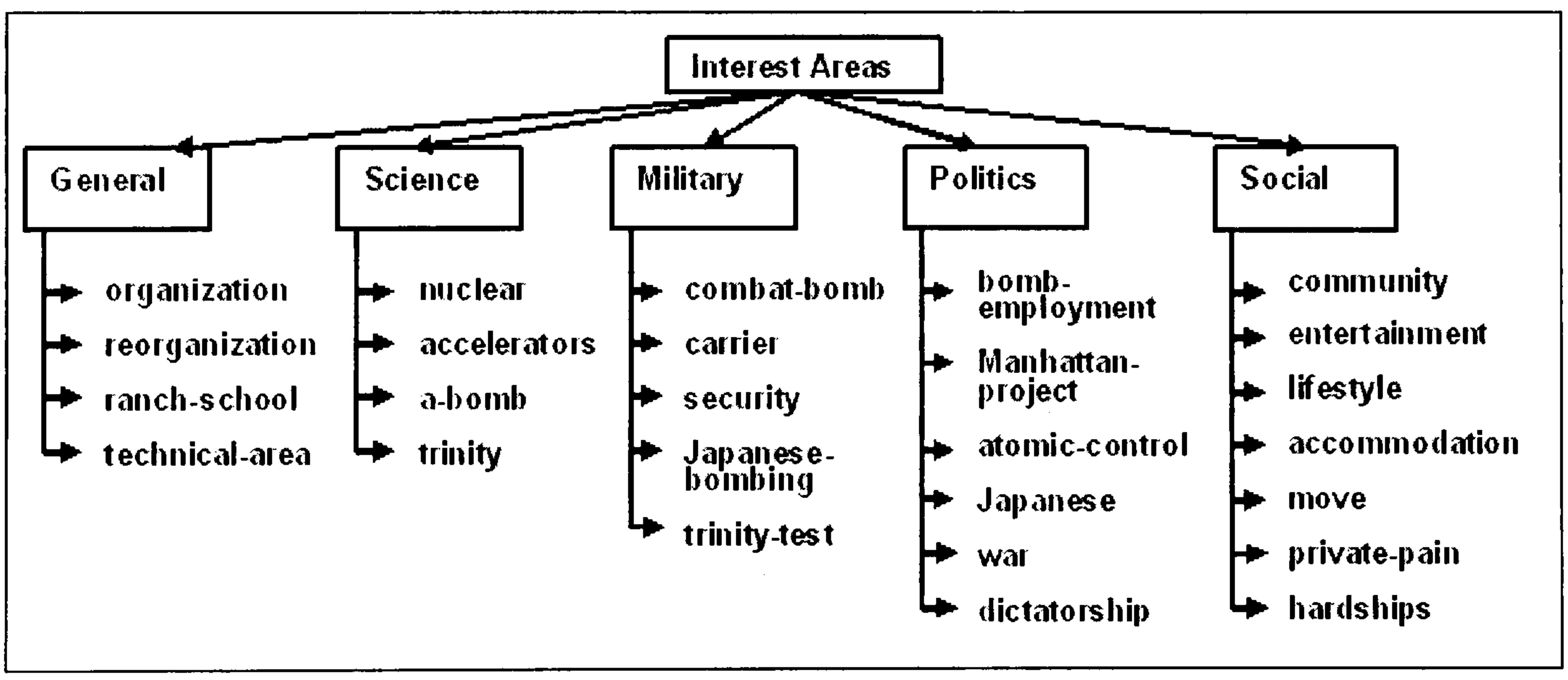


Figure 6.41: Attributes ontology for the prototype version

Besides these ontologies, our system contains definitions for basic entities, including *event, concepts, personnel* and *divisions.* On the other hand, Ibanez only provided definitions for basic *concepts.* These definitions are used to introduce related events, concepts, personnel and 'Los Alamos' divisions respectively, the first time they appear in the narrative process. These entities are tags in the story elements that serve as triggers to the remembering process during story activation and extension.

Memory Organisation

As mentioned before, the guide possesses a long-term memory that is made up of declarative memories, both semantic and emotional. Semantic memory is present in Ibanez's system, whilst emotional memory is our addition. Semantic memory is memory for facts, including location-related information, ontologies and the definition of the entities. Facts form the basic *story elements (SEs)* used to construct stories and are basically free from any ideological perspective. Each element of the guide's semantic memory is composed of the properties presented in Table 6.4 with example, referring to the *SE* in Figure 6.42.

Property	**Description**	**Example**
name	identification of the story element	*CU2*
type	the topic of story element	*Plutonium-bomb*
subjects	the subjects in the story element	*physics*
objects	the objects in the story element	*Oppenheimer, plutonium-bomb*
effects	the *SEs* that are caused by this *SE*, each effect has a weight associated	*CU3* with *weight 1*
event	a description of the event that took place, used to retrieve the guide's emotional response to the event (entity tag)	*plutonium-gun-problem*
concepts	basic entities of which the definition will be given on the first occurrence of these entities in the story (entity tag)	*plutonium*
personnel	the personnel involved in the story, not necessarily the subjects (entity tag)	*Robert-Oppenheimer*
division	the 'Los Alamos' division at which the story element happened (entity tag)	not applicable in this SE
attributes	each attribute has a weight associated and falls under one of the interest areas presented in the ontology	*a-bomb*
location	the physical location where the event occur, it can be of type "ANY" which means that the story element is general and applicable to any location, each location is also associated with a weight	*UCM*
text	the text encoding the event	refer Figure 6.42

Table 6.4: The features of story element

While the semantic memory contains facts, emotional memory is a memory for those events that have an emotional impact on the guide. Each *emotional story element (EE)* has similar structure to the *SE* without *effects* and *subjects* attributes because the *EE* itself is the effect of a *SE* and the guide itself is the subject. In addition, the following tags are included:

arousal : the arousal value when an event took place

valence : the emotional valence value when the event occurred

name	CU2
type	Plutonium-bomb
subjects	physics
objects	Oppenheimer plutonium-bomb
effects	CU3 1
event	Plutonium-gun-problem
concepts	plutonium
personnel	Robert-Oppenheimer
attributes	a-bomb 1
location	UCM 1
text	Not chemistry or metallurgy but <s> physics </s> nearly condemned the plutonium bomb to failure in summer, 1943 causing Oppenheimer to agonize over the problem to the point that he considered resigning his directorship.

Figure 6.42: Sample story elements

For sample extracts of *SEs* and *EEs*, please refer to Appendix B and Appendix C. Two perspectives are given for *EEs*, a view for a member of military personnel and a scientist's view.

Finding the Spot

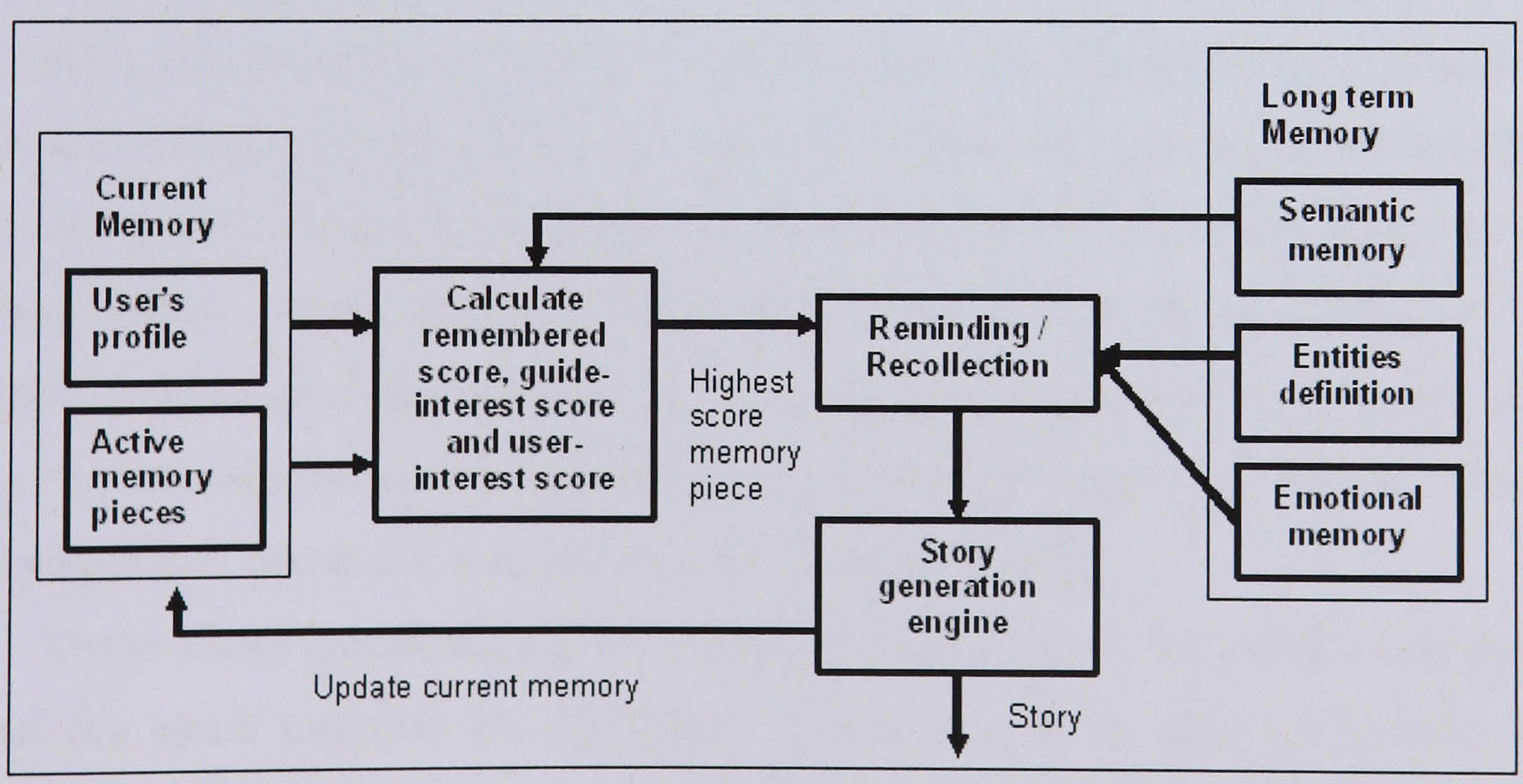


Figure 6.43: The Storytelling Process

The storytelling process, presented in Figure 6.43 starts upon arrival at a particular site of interest or when user activates the 'Tell' button. Our system determines which story to tell when arriving at a location, whereas Ibanez's system determines what to tell in advance before moving to the next location. At each step, the Affective Guide decides what to tell dynamically. The guide usually starts with a general description of the site before any interest-specific information is provided. This is achieved by assigning a higher weight to the *SEs* in the *General* interest group so that they receive higher priority. The guide's interests and the user's interests are persistent triggers of recollections and selections of stories. Additionally, the already told story elements aid recall by association of other related story elements.

Reminding is a crucial aspect of human memory and it can take place across situations. The story elements of the guide are retrieved based on processing-based reminding [Schank, 1982]. Processing-based reminding occurs during the normal course of understanding or processing new information. A *scene* or *location* is a kind of structure that provides a physical setting serving as the basis for reconstruction. Therefore, the first step involves filtering out *SEs* that are not related to the current location. This is to ensure that the *location* of the story spot always corresponds to the user location and thus, the story is relevant to what can be immediately seen. Furthermore, the changeability of dynamic memory makes people's memory act differently in apparently similar situations. We are usually reminded by similar events, those close to previously experienced phenomenon. Thus, *attributes* and *story type* are used to link and retrieve the guide's memories of similar events or circumstances. Additionally, an object or a person may also remind us of other similar or related objects or persons. Thus, *concepts* and *personnel* are also sources for remembering.

Three scores corresponding to: previously told stories; the guide's interests; and the user's interests are calculated. Ibanez's system omits user's interests, instead it calculates the spatial distance between each *SE* location and the current location as one of the scores to determine the next stop for storytelling, a time-consuming process when the number of *SEs* is large. These scores are normalised and combined to obtain an overall score for each *SE* in the current location. A *SE* with the highest overall score will become the starting spot for extension. In the current version, no preemptive information is provided, thus, links to future stories are not considered in spot selection. Only stories that relate to the user's interests, the guide's interests and to previous stories should be presented, which means that the spot needs to have an overall greater than zero value to be passed to the next and final phase. The algorithm involved in finding the spot is presented in Figure 6.44.

```
For each pair (SE, loc) ∈ PAIRS
   For each concept c ∈ concepts(SE)
         If recentMemory contains c
                  rememberedScore(pair) = rememberedScore(pair) + recentMemory(c)

For each attribute a ∈ attributes(SE)
         If recentMemory contains a
                  rememberedScore(pair) = rememberedScore(pair) + constantA

For each personnel p ∈ personnel(SE)
         If recentMemory contains p
                  rememberedScore(pair) = rememberedScore(pair) + constantP

         If recentMemory contains type(SE)
                  rememberedScore(pair) = rememberedScore(pair) + constantT

For each attribute a ∈ attributes(SE)
                  guideInterestScore(pair) = guideInterestScore(pair) +
                           attributeValue(SE, a) x guideInterestValue(a)
                  userInterestScore(pair) = userInterestScore(pair) +
                           attributeValue(SE, a) x userInterestValue(a)

For each pair (SE, loc) ∈ PAIRS
                  rememberedScore =
                           rememberedScore(pair) / maxRememberedScore
                  guideInterestScore =
                           guideInterestScore(pair) / maxGuideInterestScore
                  userInterestScore =
                           userInterestScore(pair) / maxUserInterestScore

                  overallScore(pair) =
                           rememberedScore(pair) x rememberedScoreWeight +
                           guideInterestScore(pair) x guideInterestScoreWeight +
                           userInterestScore(pair) x userInterestScoreWeight

                  spot = pair ∈ PAIRS| overallScore(pair) ≥
                           overallScore(pair') for all pair' ∈ PAIRS
```

Figure 6.44: The algorithm for finding the spot of story

In the figure, *PAIRS* is the set of SE-loc pairs such that *loc* refers to the current location, there exists an entry in the database that relates *SE* to *loc*, and the *SE* has not been narrated yet. *concepts(SE), attributes(SE)* and *personnel(SE)* give the sets of entities from the story element, *SE*. *type(SE)* denotes the type of the current *SE*. *recentMemory(c)* gives the value of the concept *c* in the current memory. *constantA, constantP* and *constantT* are fixed values between 0 and 1 that are added to the *rememberedScore* when entities in the current story element match the corresponding entities in the story elements of the previous step. *attributeValue(SE, a)* is the value associated with the attribute *a* in the *SE* while *guideInterestValue(a)* and *userInterestValue(a)* are values of the guide's interests and the user's interests respectively. *rememberedScoreWeight, guideInterestScoreWeight* and *userInterestScoreWeight* are the weights of the remembered score, guide's interest score and the user's interest score. Since we view the user's interest as the most important factor, followed by the guide's interest and finally the remembered score, these weight are in the ratio 20:15:12.

By linking the *concepts(SE), attributes(SE), personnel(SE)* and *type(SE)* to previously told *SEs*, we ensure coherency in the generated stories. The *SEs* can be related in some ways that are comparable to discourse relationships addressed by the Rhetorical Structure Theory (RST) [Mann and Thompson, 1988] including cause-effect, elaboration, purpose, sequence, etc. However, we did not divide the *SEs* into nucleus and satellite as in the RST. The value of each variable was selected depending on its importance to the story context. In the current implementation, we emphasise on relating the *SEs* based on *concepts(SE)*, taking into consideration the number of times the *concept* has been activated. The more frequent its activation, the higher its value (refer to Figure 6.47). All other variables: *constantA, constantP* and *constantT* were given the same priority with fixed values that are active only for a single story cycle. Changing these values will change the pattern of *SEs* selection and the focus of stories.

Extending the spot

After the spot has been selected, the guide proceeds to extend it. Given that one person can remind us of another person, one object can remind us of another object or one event can remind us of another event, story extension is activated based on *subject-object* links and *cause-effect* links as in Ibanez's system. Moreover, our guide uses *type, concepts, attributes* and *location* as activation factors. A story element with the *location* of type "ANY" can be activated during extension.

Two story elements A and B are connected by subject-object link if one of the following conditions is satisfied: the subject of A and B is the same; the object of A and B is the same; the subject of A is the object of B; or the object of A is the subject of B. On the other hand, if A is the cause of B; or if A is the effect of B; or if A and B are causes of the third story element C; or A and B are effects of the third story element C, then a cause-effect link is established. These story elements can be organised using a network-like structure as illustrated in Figure 6.45 so that associative activation can be performed during extension. The labelled lines are subject-object links while the red arrows show cause-effect links. Besides the subject-object and cause-effect links, the story elements can share attributes and entities.

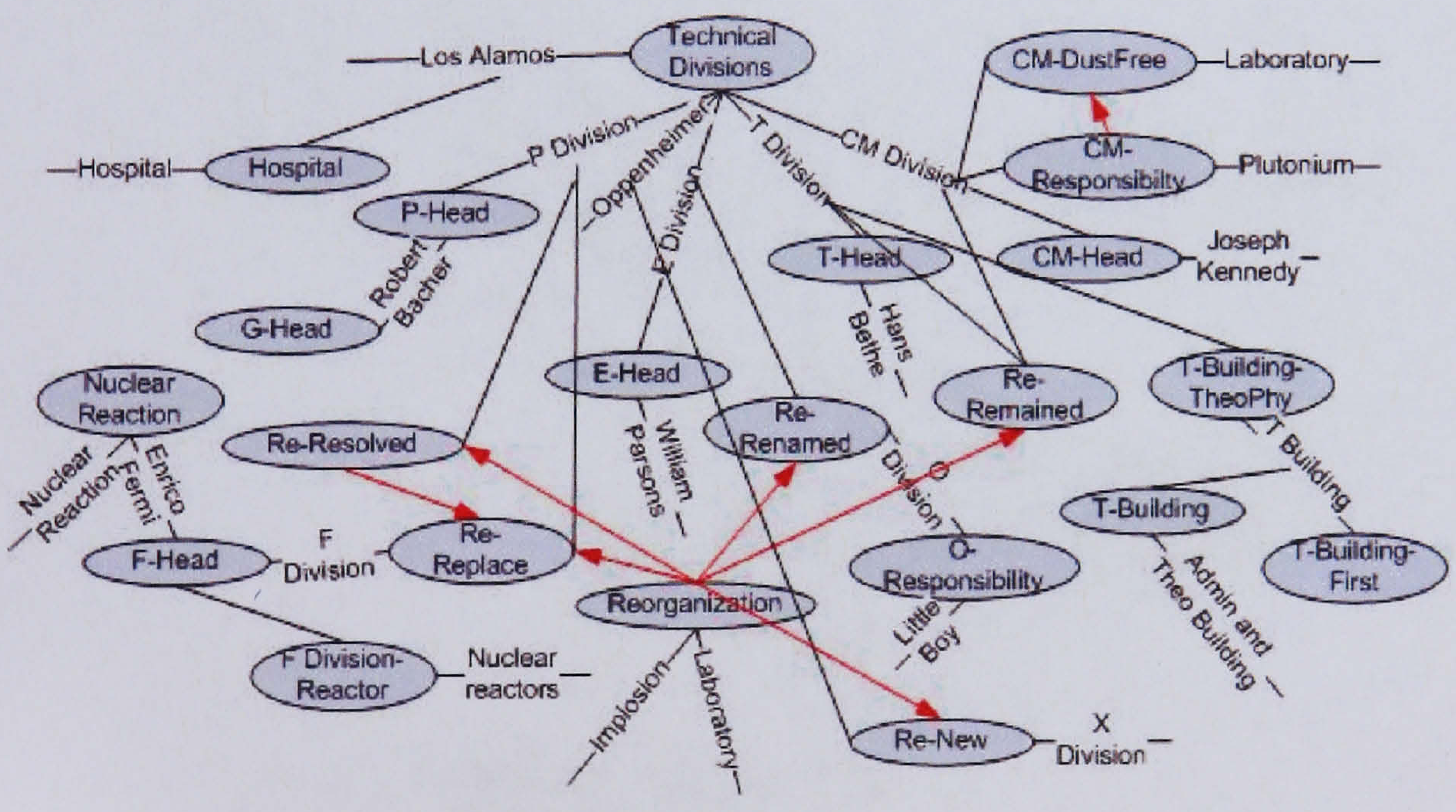


Figure 6.45: A network of the story elements

The Affective Guide story extension process is the second step in Figure 6.46. All extensions are again performed by JESS. Only *SE* that succeed the preceeding phases will continue to the subsequent phases of rule firing. The extension rules can be found in Appendix D.1. At each extension cycle, the *SE* with the highest final evaluation value is selected. If the SE is extended through cause-effect link, then it will be ordered in such a way that the effect follows the cause. On the other hand, the order of selection is preserved if the SE is selected through the firing of subject-object link. When the desired granularity is reached and the combination of the story elements is large enough to generate a short story, the extension process is complete.

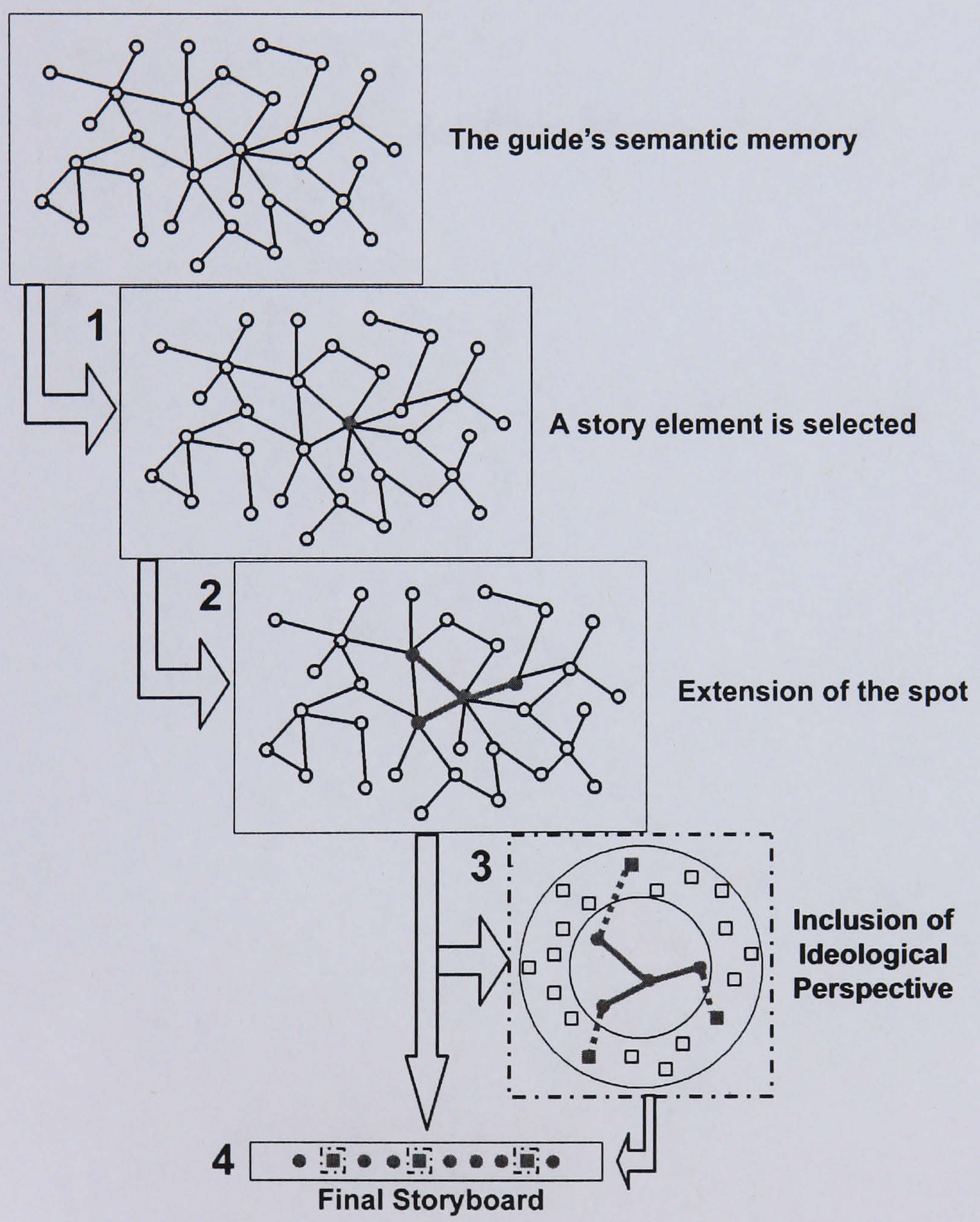


Figure 6.46: The Story Extension Process (modified from Ibanez [2004])

Ideological Perspective

Whilst it is true that the Affective Guide tells facts, at the same time it should not hide its feelings, beliefs and opinions. Hence, it includes its own experiences related to the facts during the storytelling, just as a real guide does. These experiences or events can be related to itself or others. We construct the guide's perspective from its emotional memory elements which lead to re-experience of emotions but with variation due to the user's input. On the other hand, Ibanez generates perspective information by inferences based on the guide's profile and expression rules, with pre-defined attitudes and emotions.

It is noteworthy that the Affective Guide includes its ideological perspectives only if it is currently competent and highly certain of the user's interests, in other words, when its *resolution level* is high enough. Referring to Figure 6.46 again, this step is represented by the process in the dotted frame. The *EEs* are selected based on the activated *SEs* to ensure a smooth flow of storyline. To reduce complexity in the current version, a *SE* will lead to inclusion of only one *EE*. Hence, the number of *EEs* added is always less than or equal to the number of *SEs*. The rules in Appendix D.2 are applied for retrieval of *EEs*.

Generating the Story

The result of the above steps is a set of inter-related story elements and optional emotional story elements. These elements are stored in a structure with meta information about the extension process, including the relations among them, the reason for selection and the evaluation values. With this information, the system is ready to generate a complete story.

Since the set of *SEs* has been ordered during extension process, the next step is to order the *EEs*, where available. Each *EE* usually follows its associated *SE*. However, if two *SEs* have a cause-effect relationship, then the associated *EEs* will come after both *SEs*. Next, all the selected elements are combined taking into consideration the existence of *entities*. The guide retrieves the definition for each *entity*, (*event, concept, personnel* and *division*) that appears for the first time whether in *SEs* or *EEs*. This recall process - Schank [1982] termed this dictionary-based reminding - occurs when we search for the definition of an infrequent word or concept in our memory.

Each *subject* in the *SE* text is embraced in begin and end tags defined as

<s> and </s> (please refer to Figure 6.42 for an example). These tags allow the system to recognise the *subject* of the *SE* and substitute it with an appropriate pronoun, retrieved from the database. With the completion of this step, the final storyboard is obtained. The resulting story is sent to the PDA and presented to the user. After each story presentation, the guide updates its current memory so that it can be reminded of the current active memory elements in the next retrieval cycle. We have seen that the guide stores the current activation of *concept, personnel, attribute* and *type* in its recent memory. Analogous to human memory, a *concept* strength in the guide's memory increases when it is activated frequently and will be forgotten if not used after a few iterations. In contrast, the current activation of *personnel, attribute* and *type* remain in the current memory only for a single story cycle. In Ibanez's system, once a *concept* is activated, it will never be completely forgotten. The reinforcement and forgetting of *concept* strength are performed using the algorithm in Figure 6.47.

```
Reinforcement
First appearance of a concept
For each concept c ∈ conceptsJustUsed and c ∉ previouslyUsedConcepts
        recentMemory(c) = 1

Successive appearances of a concept
For each concept c ∈ conceptsJustUsed and c ∈ previouslyUsedConcepts
        recentMemory(c) = recentMemory(c) x timesOfAppearance(c) x
                reinforcementMemoryFactor

Forgetting
For each concept c ∉ conceptsJustUsed and c ∈ previouslyUsedConcepts
        recentMemory(c) = recentMemory(c) - forgetMemoryFactor
        If recentMemory(c) ≤ 0
                remove recentMemory(c)
```

Figure 6.47: Algorithm for reinforcement and forgetting of *concept* strength

conceptsJustUsed refers to the list of concepts that is active in the current story telling cycle while *previouslyUsedConcepts* refers to the list of concepts that was active in preceeding cycles. *timesOfAppearance(c)* is the number of times c appears in the current cycle. *reinforcementMemoryFactor* specifies the degree of enhancement whilst *forgetMemoryFactor* defines the degree of forgetting of a concept c in the guide's memory.

6.3 Overall Process

Now, let's take a look at some sample cases of how the storytelling system works in concert with the emergent emotion model to perform adaptation of the Affective Guide's emotions and behaviour based on the user input. Instead of just behaviour adaptation based on emotional states, we also examine how the emotional states influence the guide's belief system. Please note that the belief system referred to here is the guide's belief about the user's interests and how it should act in response to the user's feedback rather than the ideology it holds on the atomic bomb issues (for detail, please refer to Section 4.1).

Case 1: If the guide's prediction about the user's interests is correct (high certainty) and the user perspective is consistent with that of the guide (high competence), the guide may experience low to medium *arousal level* and *selection threshold* with a medium *resolution level.* In this case, the guide may be said to experience pride because it can master the situation. It is not so easy for another goal to take over. The guide will perform some planning and provide a more elaborate story on the current subject, including its active ideological perspective.

The guide's belief about the user's interests is srengthened. This is consistent with the argument of Fiedler and Bless [2000] in which an agent experiencing positive affective states fosters assimilation that supports reliance and the elaboration of its existing belief system. The positive feedback during information processing is experienced as success feedback, leading to continuous reliance on its current beliefs as suggested by Clore and Gasper [2000].

Case 2: If the guide's prediction about the user's interests is right (high certainty) but the user's perspective is in conflict with the guide's ideology (lower competence), then the *arousal level* of the guide may be higher than in the previous case. The *resolution level* decreases while the *selection threshold* increases. In this case, the guide will have some difficulties in coping with the differing perspective, but since it has anticipated the situation, it is motivated to concentrate on the specific goal and gives a more general view on the issues instead of presenting them from its own ideological standpoint.

Due to the user's disagreement with the guide's arguments, there is a need to overcome the discrepancy [Harmon-Jones, 2000]. The negative affect is taken as a failure feedback, leading to requirements for new information and inhibiting the application of current accessible beliefs. Thus, the guide performs adjustment to the story topic by modifying its own interest on the related topic.

Case 3: In the case that the guide's prediction about the user's interests is wrong (low certainty) but the user's perspective is consistent with the guide's ideology (high competence), .the *arousal level* of the guide may be equal to or lower than the second case. The guide is still in control of the situation making the uncertain environment look less threatening. Nevertheless, the guide may be disappointed in relation to its wrong prediction. The *selection threshold* decreases and the *resolution level* increases. Since the guide is experiencing a negative emotional state, it performs more detailed and substantive processing that will lead to mood repair. Its action involves a high user's input fidelity where the information is utilised to change its beliefs about the user's interests. This again is supported by the discussion of Fiedler and Bless that negative states trigger accommodation processes, allowing beliefs to be updated.

Case 4: On the other hand, if the guide's prediction about the user's interests is wrong (low certainty) and the user's perspective is in conflict with the guide's ideology (low competence), the *arousal level* of the guide will be very high. It is reasonable to react quickly, concentrate on the relevant task and refrain from time consuming memory search. Therefore, the *selection threshold* will be high while *resolution level* should be low, in which case, we may diagnose that the guide is experiencing anxiety. In this situation, the guide tends to give a brief story of the current site without details.

A biasing effect occurs. The high arousal value prevents careful attention to external stimuli and calls for a prompt response. Hence, the guide will focus on a particularly active goal and perform the goal as quickly as possible without further consideration. The current situation will be fedback to the system so that the guide can adjust its beliefs appropriately to better cope with the situation in future.

6.3.1 Intention Execution

From the above cases, it can be deduced that UPDATEBELIEF occurs when the user dislikes the stories, implying that the guide's prediction about the user's interest is incorrect. In such a situation, the guide will first explore the database to retrieve the currently presented *SEs*. Having the *SEs*, it determines the associated attributes, for example 'nuclear', 'a-bomb', etc., it then updates its current memory about the user's interests by decreasing the weight for these attributes. At the same time, it also decreases the weight of the attributes in its own interest memory so that the probability of stories with the same attributes being selected in future reduces.

NEWTOPIC on the other hand, usually occurs when the user disagrees with the guide's argument, that is when the guide's *need for competence* is high. Since the arguments are present in the currently presented *EEs*, the guide retrieves the attributes associated with these *EEs*. Next, the guide updates its emotional memories, where the *EEs* with the same attributes as the current *EEs* are reduced in weight. Additionally, it explores the attributes of the currently presented *SEs*. The reason for taking the *SEs* into consideration is because the *EEs* are extended based on them. So, in order to prevent more disagreement from the user on the same issue, the root of the problem needs to be dealed with. As in UPDATEBELIEF, it performs an update for the attributes of the current *SEs* with the exception that, this time, only its own interest memory is updated, not the user's. By doing so, it gradually shapes the stories to the user's interests.

In all cases, the execution will end with story presentation by the guide. Therefore, STORYTELLING is always performed unless there is no story available. The extensiveness of story generation depends on the guide's current emotional state, particularly the *resolution level*. Normally after UPDATEBELIEF or NEWTOPIC, a quick response is required as the guide has a high *need for certainty* or a high *need for competence*, causing it to perform shallow planning and thus generate short stories.

6.3.2 Example Stories

Presentation of an emotional guide with low level of resolution:

The first Japanese bombing target, Hiroshima was of such size that the damage would be confined within it, so that definite power of the bomb could be determined. Little Boy exploded at 8:16:02, August 6, 1945, Hiroshima time, one thousand nine hundreds feet above the courtyard of Shima Hospital, with a yield equivalent to twelve thousands five hundred tons of TNT. Trinitrotoleune or TNT is a pale yellow crytalline aromatic hydrocarbon compound that melts at eighty one degree Celcius. It is an explosive chemical used on its own or in many explosive mixtures such as Torpex, Tritonal, Composition B or Amatol. It is difficult to dissolve TNT in water; it is more soluble in ether, acetone, benzene and pyridine. The explosive yield of TNT is considered the standard measure of strength of bombs and other explosives.

Presentation of an emotional guide with medium level of resolution:

The first Japanese bombing target, Hiroshima was of such size that the damage would be confined within it, so that definite power of the bomb could be determined. Little Boy exploded at 8:16:02, August 6, 1945, Hiroshima time, one thousand nine hundreds feet above the courtyard of Shima Hospital, with a yield equivalent to twelve thousands five hundred tons of TNT. Trinitrotoleune or TNT is a pale yellow crytalline aromatic hydrocarbon compound. Its explosive yield is considered the standard measure of strength of bombs and other explosives. The important result of Hiroshima bombing and the one that we sought, was that it brought home to the Japanese leaders the utter hopelessness of their position. When this fact was reemphasized by the Nagasaki bombing, they were convinced that they must surrender at once. The Air Force is operating primarily to laying waste all the main Japanese cities. Their procedure had been to bomb the hell out of Tokyo, bomb the manufacturing and assembly plants, and in general paralyze the aircraft industry so as to eliminate opposition to its operations.

Presentation of an emotional guide with high level of resolution:

The first Japanese bombing target, Hiroshima was of such size that the damage would be confined within it, so that definite power of the bomb could be determined. Little Boy exploded at 8:16:02, August 6, 1945, Hiroshima time, one thousand nine hundreds feet above the courtyard of Shima Hospital, with a yield equivalent to twelve thousands five hundred tons of TNT. Trinitrotoleune or TNT is a pale yellow crytalline aromatic hydrocarbon compound. Its explosive yield is considered the standard measure of strength of bombs and other explosives. The important result of Hiroshima bombing and the one that we sought, was that it brought home to the Japanese leaders the utter hopelessness of their position. When this fact was reemphasized by the Nagasaki bombing, they were convinced that they must surrender at once. The Air Force is operating primarily to laying waste all the main Japanese cities. Their procedure had been to bomb the hell out of Tokyo, bomb the manufacturing and assembly plants, and in general paralyze the aircraft industry so as to eliminate opposition to its operations. With the success of the Hiroshima weapon, the pressure to be ready with the much more complex implosion device became excruciating. We felt that the sooner we could get off another mission, the more likely it was that the Japanese would feel that we had large quantities of the devices and would surrender sooner.

Figure 6.48: Stories by the Affective Guide with different *resolution level*

In the current prototype, the granularity of the story has been set to 2, hence at each story generation cycle, the guide will select a spot accompanied by an extension of at most one story element. Depending on its *resolution level*, it will then link these elements to its ideological perspective. Figure 6.48 provides some examples of the stories generated by the guide under different emotional states.

6.4 2D Guide Character

Boehner et al. [2005] suggest that affect in computer systems can be seen as information or as interaction. Seeing emotional experiences as information is affective computing. In contrast, affect seen as interaction involves construction and active interpretation of emotions, which allows a user-centred approach where the user can be in control of what emotions are expressed and to some extent create their own interpretation of the emotional expressions. Hence, the approach taken here is to build the Affective Guide based on patterns that are familiar to the user but without explicit labelling of the generated emotions.

The internal states of the Affective Guide are reflected through a simple 2-dimensional animated talking head and a colour bar. This shows dynamic expressions that are directly related to the guide's internal states. Facial expression is a vital part of the guide as expression plays a critical role in social interaction with people. The idea of using simple animation and colours for expressing emotions is appropriate in an interface where computational resource is scarce, as with a PDA. The following subsections provide descriptions of our approach to emotion expression.

6.4.1 Facial Mapping

The review in Section 3.5 of Chapter 3 showed that arousal has the greatest impact on the eyes. This is consistent with the finding that fear - implying arousal - can be most effectively detected through the eyes [Morris et al., 2002] and that the pupil size is more significantly influenced by the level of arousal than of valence [Partala et al., 2000]. On the other hand, valence affects the mouth curvature. As well as the eyes and mouth, we take into consideration the eyebrows, which have been found to be as influential in facial expression recognition [Sadr et al., 2003]. The movement of the eyebrows alone may be enough to form some emotional expressions. For example, referring to Figure 3.22 (Section 3.5), in the expression of sadness, AU 1 or a combination of 1+4 occurs; in surprise, the combination 1+2 occurs; and in anger, AU 4 occurs [Ekman, 1979]. Lowered eyebrows usually signify anger or high dominance while raised eyebrows express low dominance such as sadness or fear [Knutson, 1996]. By combining the eyebrows with other facial movements, the entire range of human emotions can be produced.

Using the information gathered, we propose a simple novel approach of facial expression mapping onto the emotional space. This approach is flexible and able to produce an infinite range of expressions. We mapped three facial features: the eyes, the mouth and the eyebrows onto the arousal and valence dimensions where each dimension influences a facial feature more strongly than the others. The valence value moving from negative to positive will move the lip curvature from a downturn U to an upturn U as depicted in Figure 6.49. A value from 0 to 0.5 denotes negative valence while a value greater than 0.5 represents positive valence. In the case of extreme pleasure, as Duchenne stresses, the cheek raiser is visible below the eyes. In contrast, for extreme displeasure, wrinkles are formed beside the wing of each nostril due to the action of the naso-labial fold as Darwin put it. Along the arousal dimension, the size of eye opening increases with increasing arousal and reduces with decreasing arousal as shown in Figure 6.50.

Figure 6.49: The lip curvature change along the valence dimension

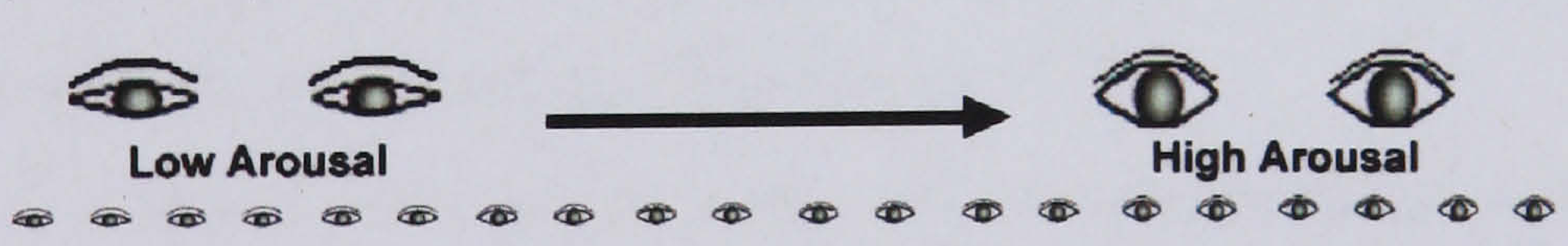


Figure 6.50: The eyes opening along the arousal dimension

As for the eyebrows, they are influenced by both the arousal and valence values. Under positive valence, when arousal is low to medium (less than 0.5), the eyebrows will have a slight V curve. The eyebrows become more and more relaxed and straightened with increasing arousal. When arousal is very high (more than 0.8), the eyebrows will be raised slightly and the raised inner eyebrows cause delicate wrinkles to be formed across the forehead as presented in Figure 6.51. On the other hand, Figure 6.52 shows that the opposite takes place when valence is negative.

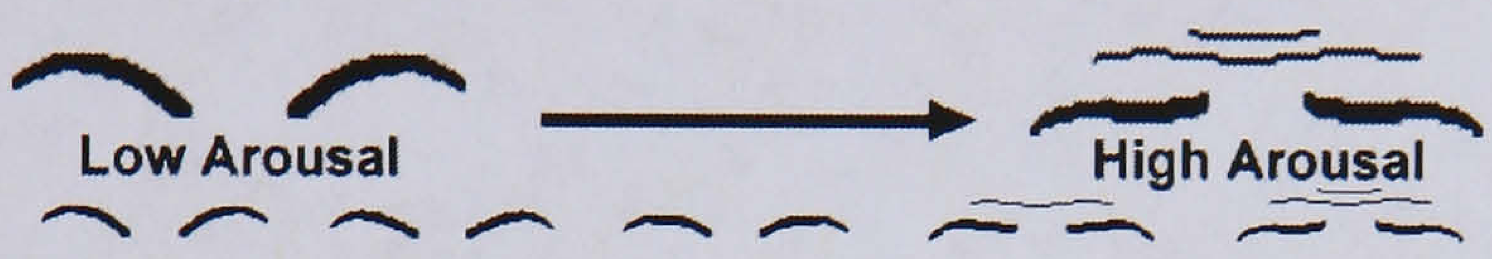


Figure 6.51: Movement of the eyebrows along the arousal dimension when valence is positive

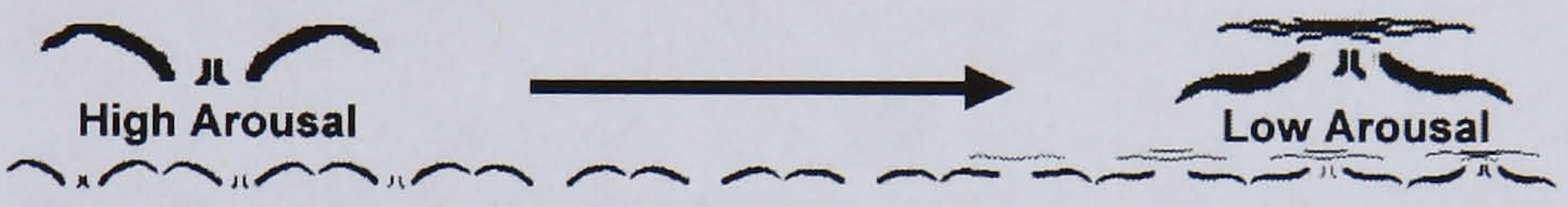


Figure 6.52: Movement of the eyebrows along the arousal dimension when valence is negative

If arousal is very high, the inner eyebrows curve downwards forming a V. The knitting of the inner eyebrows causes furrows to be observed especially when the arousal becomes too high. On the other hand, as arousal decreases, the curve will smoothen and become more and more relaxed. Nevertheless, when arousal falls below neutral (less than 0.5), the curve becomes an upturned V and in the extreme case, forms vertical furrows above the base of the nose, with transverse wrinkles across the forehead. The resulting facial expressions along the arousal and valence dimensions are shown in Figure 6.53.

In the current version, animation of the facial expressions is performed by swapping facial feature frames given that the .NET Compact Framework 1.1 of Visual Studio.NET 2003 provides support neither for real-time animation nor for morphing. Ten frames are generated for each facial feature, so the frames are distributed across 0.1 intervals in the dimensional space. From the figure, it can be seen that a wide variation of facial expressions can be generated even with such a limited number of frames per feature, implying that an infinite variation could be achieved if morphing is possible.

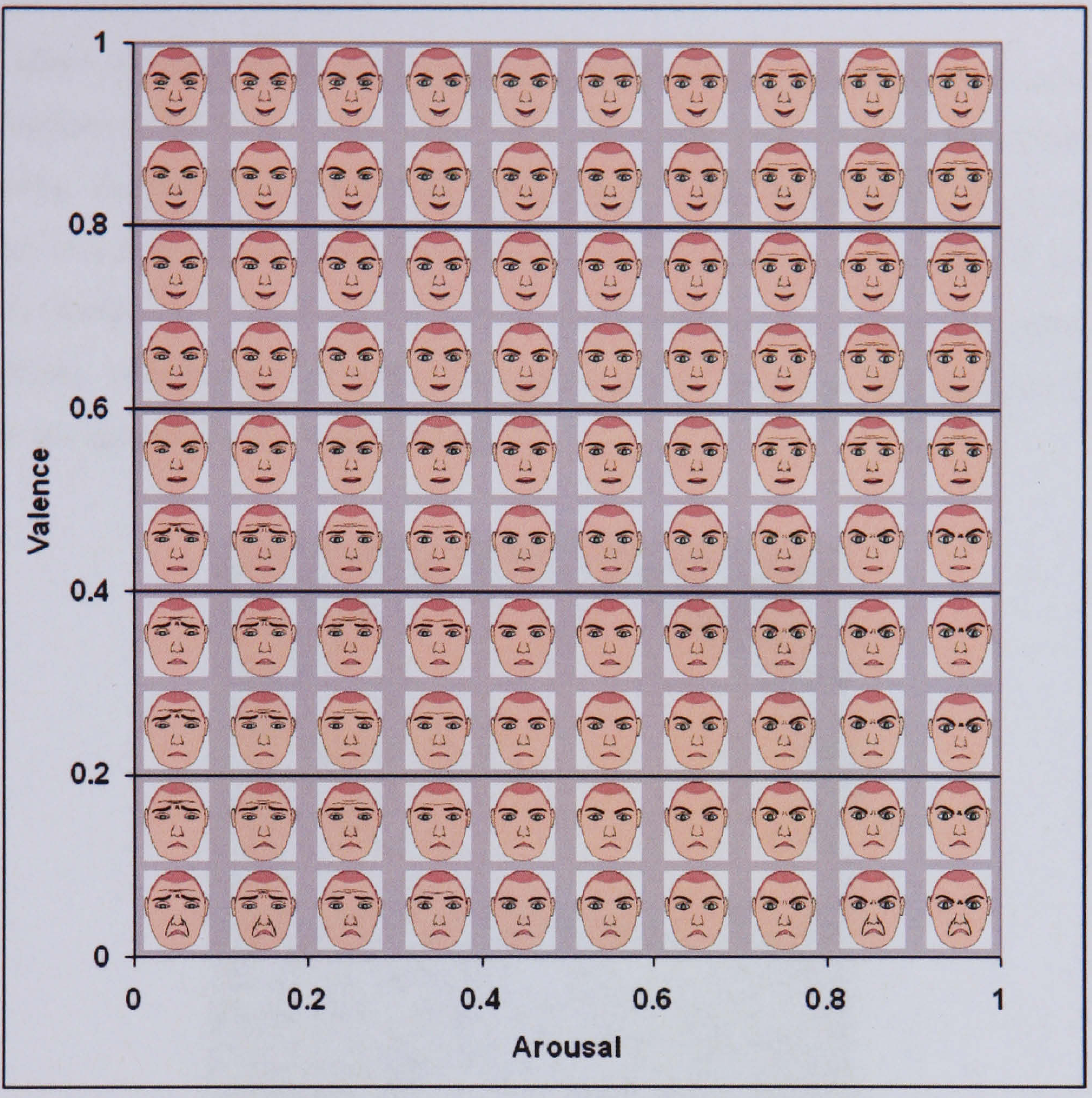


Figure 6.53: Different facial expressions on the arousal-valence space

Whenever the guide is idle, that is when it is not telling stories, it blinks from time to time to increase its naturalness. Although only simple animation is applied, the nuances of the underlying emotional assessment (arousal and valence) can be reflected. This approach provides a robust and flexible architecture where emotion expressions are not limited to the basic discrete expressions but span a continuous space with infinite combinations provided morphing can be performed. It matches the underlying architecture's avoidance of labelled emotional states.

6.4.2 Internal States

The effect of colour on mood and feeling is well-known [Wagner, 2006]. Although perceptions of colour are somewhat subjective, some colour effects have universal meaning. Red is used to show high arousal as it is usually perceived as the most energetic colour, while blue represents low arousal and calmness. On the other hand, Goethe [von Goethe, 2006] defines colours as having negative and positive qualitites, referring to the circle from green, yellow to red as the positive side, while its opposite is the negative side.

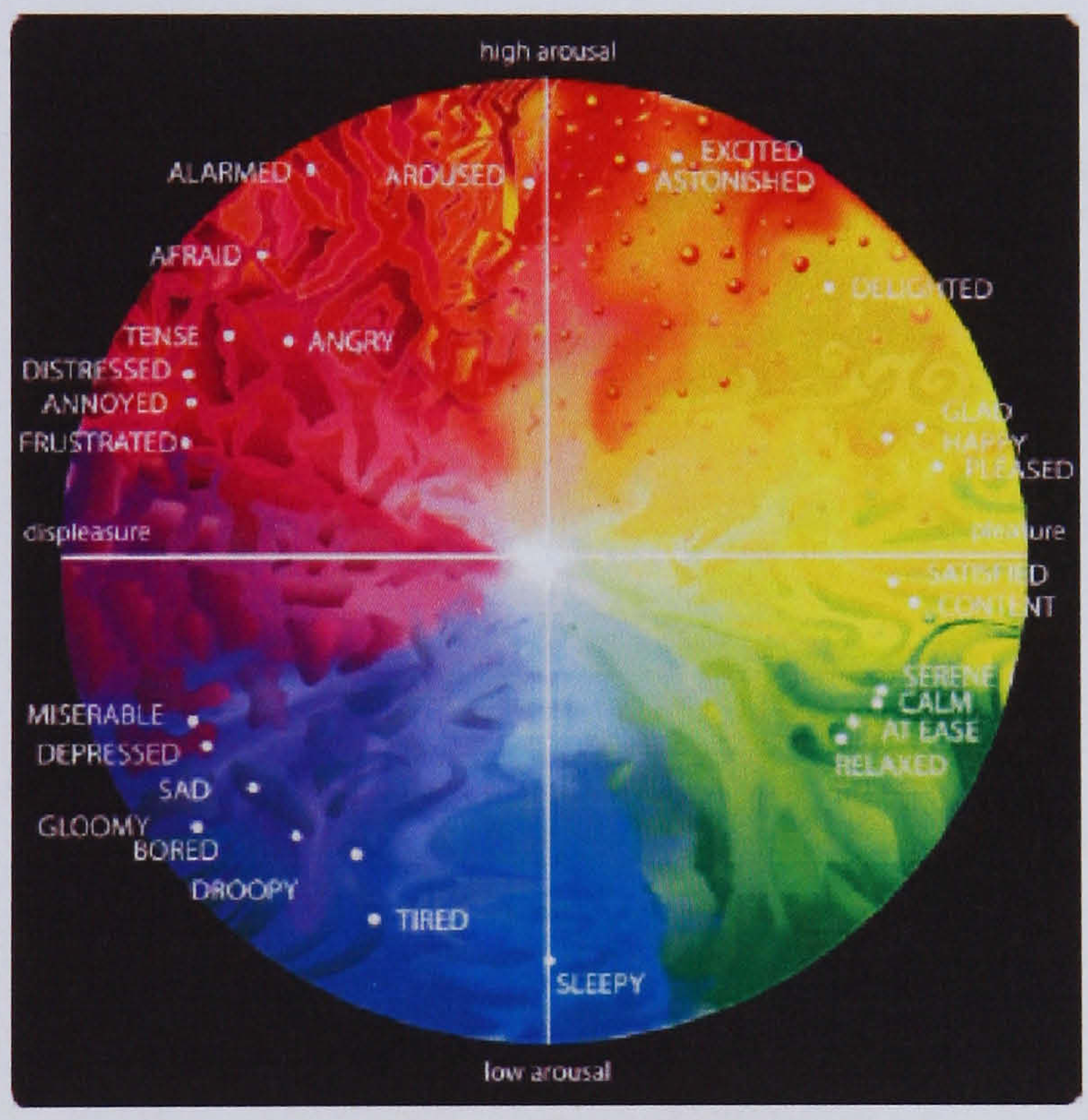


Figure 6.54: eMoto's affective circle (from Fagerberg et al. [2004])

An example application that applies colour psychology for emotion expression is *eMoto* [Fagerberg et al., 2004]. *eMoto* is a text messaging service that allows the user to write a text message and then adjusts the affective background to fit the text. Emotions are seen as continuous states that blend into one another and Russell's *Circumplex Model* serves as the basis for interaction. The user moves around the circular space of emotions expressing the arousal and valence of their emotional state through combinations of two basic movements. The intensity of hand movement determines the arousal value, while the pressure imposed on the stylus represents the valence value. In addition to colour, emotions are also expressed using shape and animation. Figure 6.54 shows the circumplex model used in *eMoto*.

To reflect the internal state of the Affective Guide, colour psychology is applied as in *eMoto* but eliminating shape and animation. This is achieved by mapping the arousal and valence dimesions onto the colour wheel. The colour displayed on the colour bar beside the guide's face is calculated based on the arousal and valence values with respect to the red, green and blue components using the conditions and equations in Figure 6.55. The resulting mapping is presented in Figure 6.56.

```
        green = Min(255, 255(valence))

if valence is > 0.75
        red = Min(255, 255(valence))
        blue = Min(255, 255(1 - valence))
else
    if arousal > 0.5
        red = Min(255, 255(2 x arousal - 1))
        blue = Min(255, 255(1 - arousal))
    else
        blue = Min(255, 255(1 – 2 x arousal))
        red = Min(255, 255(arousal))
```

Figure 6.55: Color calculation

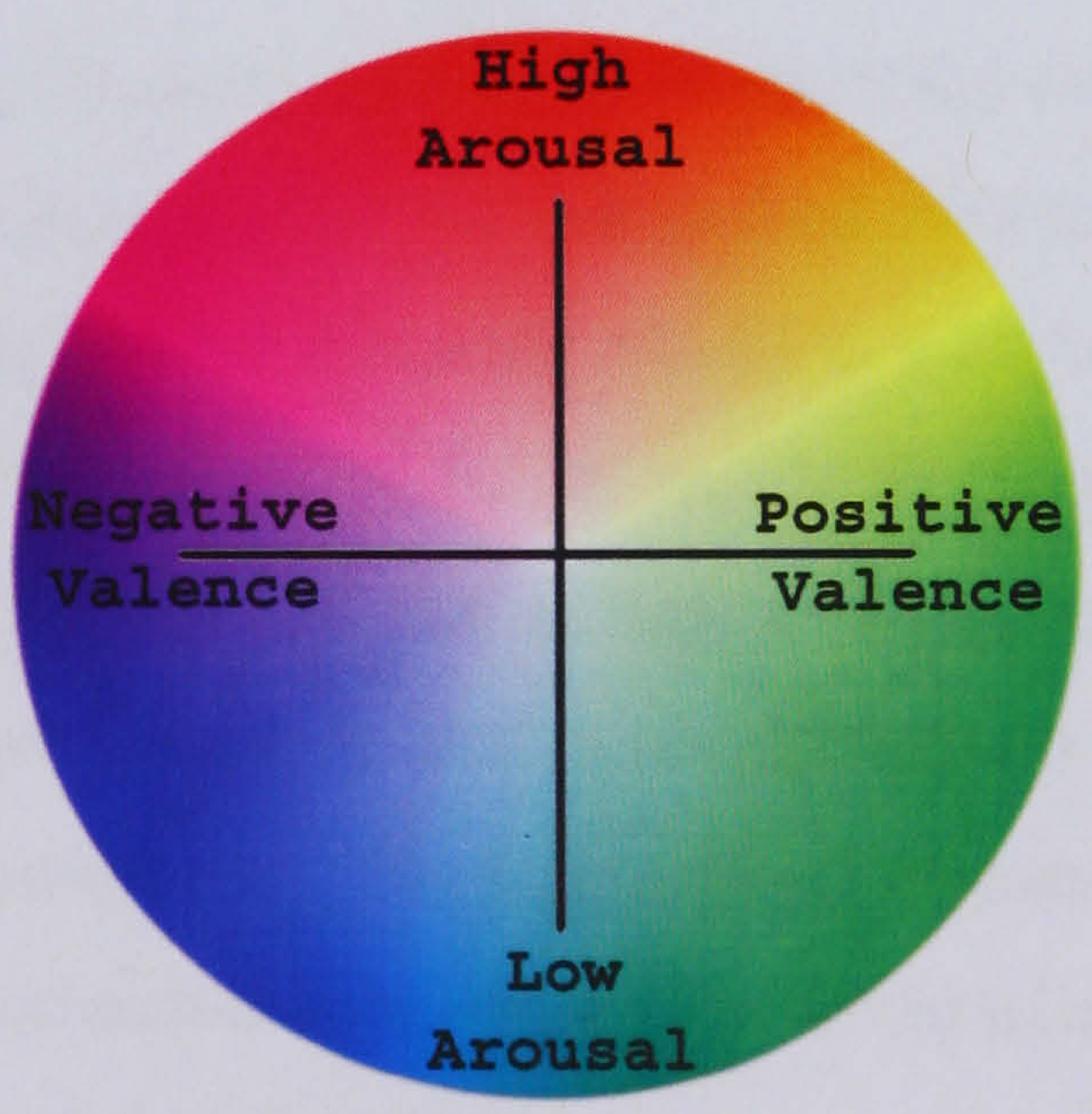


Figure 6.56: Emotional Color Wheel

6.4.3 Mouth Animation

A set of mouth frames has also been generated for animation corresponding to speech. Instead of mapping the visual frames onto the phonemes, they are mapped onto alphabetical and integer sets. When the guide speaks, starting with the first character in the text, every third alternating character is extracted to determine the appropriate frames to be displayed. Although this approach is simple, it is sufficient to create a convincing mouth animation. Figure 6.57 presents the mouth frames and its corresponding alphabetic and integer elements.

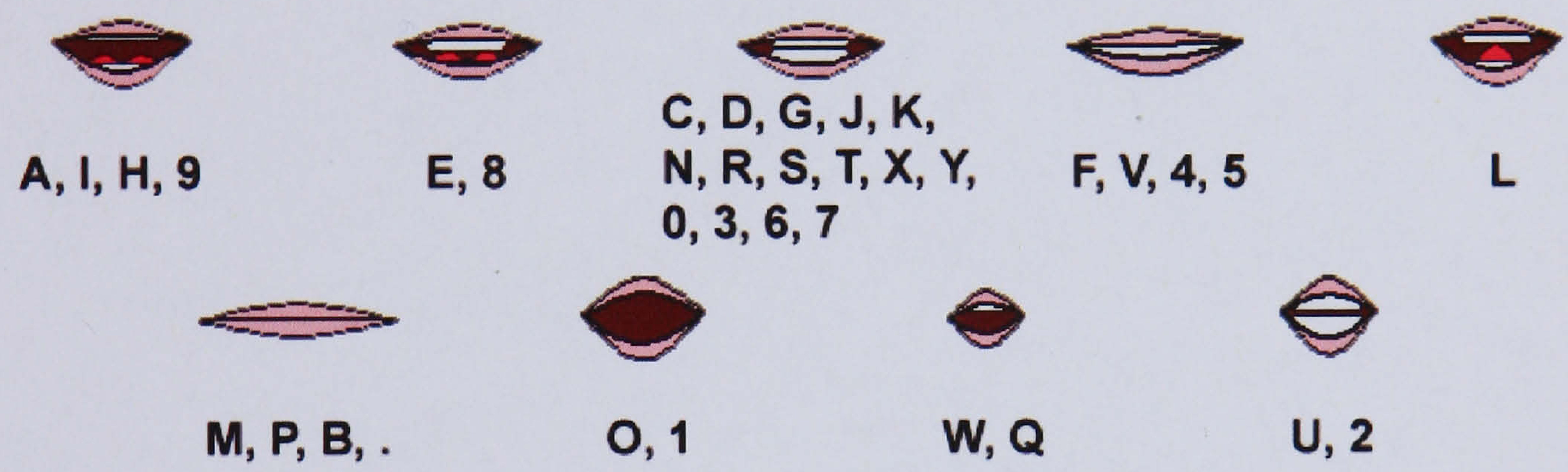


Figure 6.57: The mouth animation frames

6.5 Summary

This chapter provides a detailed explanation of the novel element of this thesis, the Emergent Emotion Model including the storytelling system and the 2-dimensional guide character. The Emergent Emotion Model is a biologically inspired model allowing creation of a believable guide. It regulates the guide's internal states, which subsequently affect the guide's behaviour and processing strategy. The emotions of the Affective Guide are not explicitly defined but emerge from modulation of information processing. The interaction between the built-in motivators and the modulators produces a complex and wide variation of behaviours in the guide that can be termed as emotional.

The guide performs improvisational storytelling and adapts its story presentation based on its emotional state. Its internal state is reflected through facial expressions and a colour bar based on colour psychology. Parallel with the emerging emotions, a flexible mapping that may generate an infinite number of facial expressions has been developed.

Chapter 7

Experiments

Doubt can only be removed by action

- *Johann Wolfgang von Goethe. German Playwright, Poet, Novelist and Dramatist. 1749-1832*

If you don't make mistakes, you aren't really trying

- *Coleman Hawkings. American jazz musician, 1904-1969*

This chapter starts with a demonstration of how the inclusion of the emergent model changes the behaviour of the guide. The main aim of the emergent model is to increase the naturalness and intelligence of the virtual guide by regulating its behaviour, hence making it more believable. The addition of attitude is expected to make the guide more expressive, as well as the stories more lively and interesting, so that it can enhance tour experience and generate a long term memory effect in the user.

In order to investigate whether the addition of emotions and attitude to the virtual guide is perceived as positive by users, experiments with real users were designed to measure enhancement in the tour experience that it provides. The test was divided into two phases: a pilot test and the full evaluation. In addition, users were tested on their recall of the information presented by the guide to verify whether a higher level of remembrance is generated in the emotional guide's users.

7.1 Adaptive behaviour

The emergent model is added to govern the guide's behaviour so that its reactions correspond to the circumstances of the external environment. In order to show how the guide is adapting its behaviour, a set of data (see Appendix E) has been devised for simulation. This data is fed into the emotional guide so that the changes in performance can be observed.

Figure 7.58: Changes in needs corresponding to external feedback

Figure 7.59: Correlation between motivators and modulators values

Figure 7.58 presents the changes in needs corresponding to the inputs (the user's degree of interest in the stories, the user's degree of agreement to the guide's arguments, system feedback, and GPS information) from the interaction environment. System feedback refers to the success or failure of the previous iteration with 1 being success and 0 being failure. From this chart, it can be observed that the *need for competence* is inversely correlated to system feedback and the user's degree of agreement to the guide's arguments while the *need for certainty* is influence by GPS reliability and the degree of interest of the stories. Next, Figure 7.59 illustrates how the changes in needs affect the values of the modulators. As needs increase, *arousal* increases too. The *selection threshold* is directly proportional, while the *resolution level* is inversely proportional, to the *arousal.*

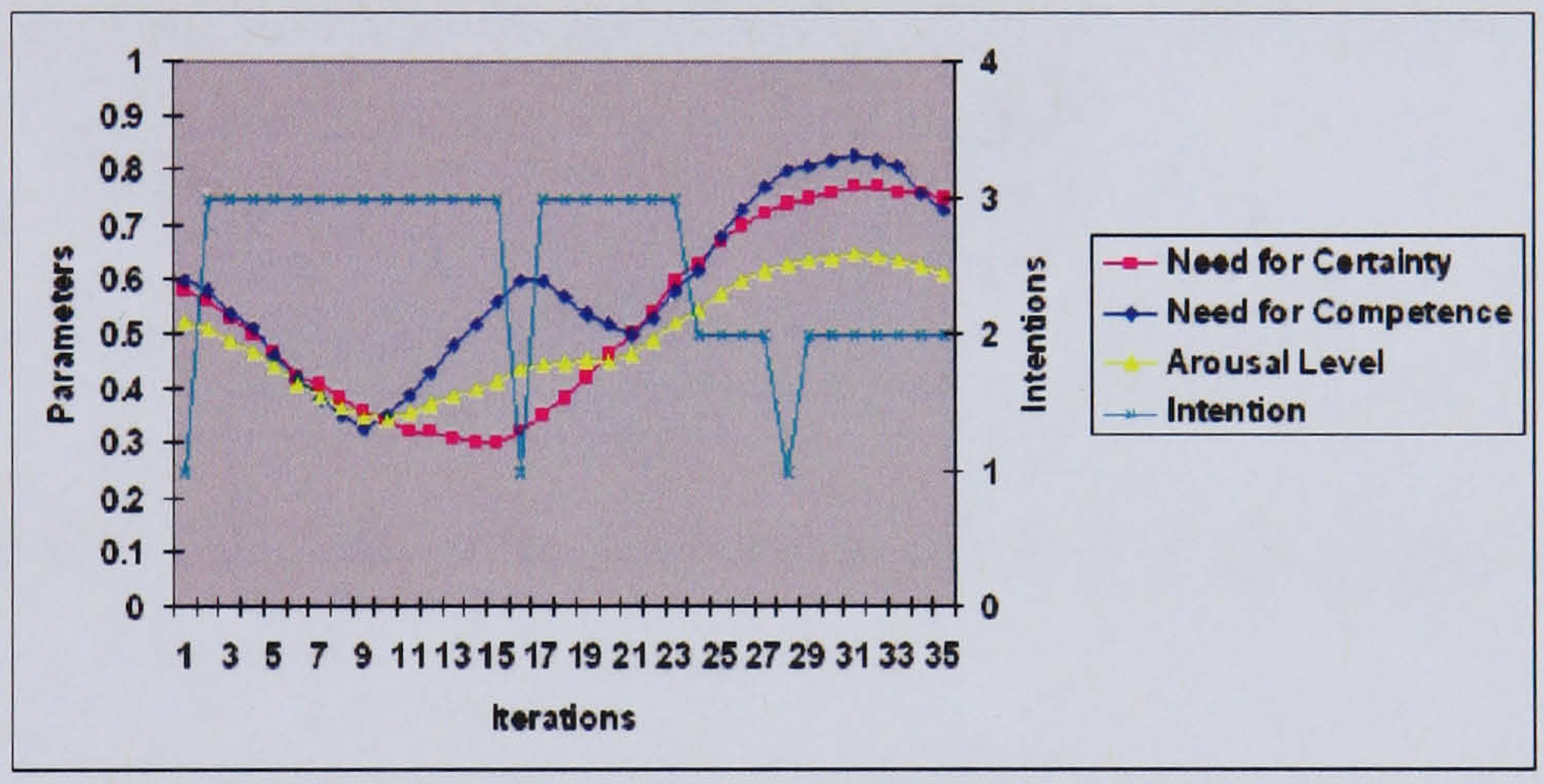


Figure 7.60: Intention selection based on motivators values

Figure 7.60 shows the impact of motivator values on the choice of intention. Intention 1 represents NEWTOPIC, Intention 2 represents UPDATEBELIEF and Intention 3 denotes STORYTELLING. When *arousal* is high, caused by an increase in the need for certainty, the guide tends to update its beliefs about the user's interests. When *arousal* is high as a result of an increase in the need for competence, the guide tends to adjust the story topic and presentation. When *arousal* is medium to low, the guide will perform storytelling.

Besides simulating the changes in state for the emotional guide, the effect of changes in the weights of the modulating parameters on the processing style is also generated. These simulation are carried out by changing only the weight of one parameter each time to see its effect on the personality (in terms of behaviour) of the guide. For all the above simulations, a weight of 0.75 is used for all modulators (*arousal, resolution level* and *selection threshold*). Figure 7.61 show a change in *arousal* weight from 0.75 to 0.25. As weight is reduced, the *arousal* values of the guide decrease, leading to a drop in *selection threshold* and a boost in *resolution level.* Thus, a guide with higher *arousal* weight will be more impulsive and firm in its decision than a guide with a lower *arousal* weight.

Figure 7.61: Modulator values for a guide with 0.25 *arousal* weight

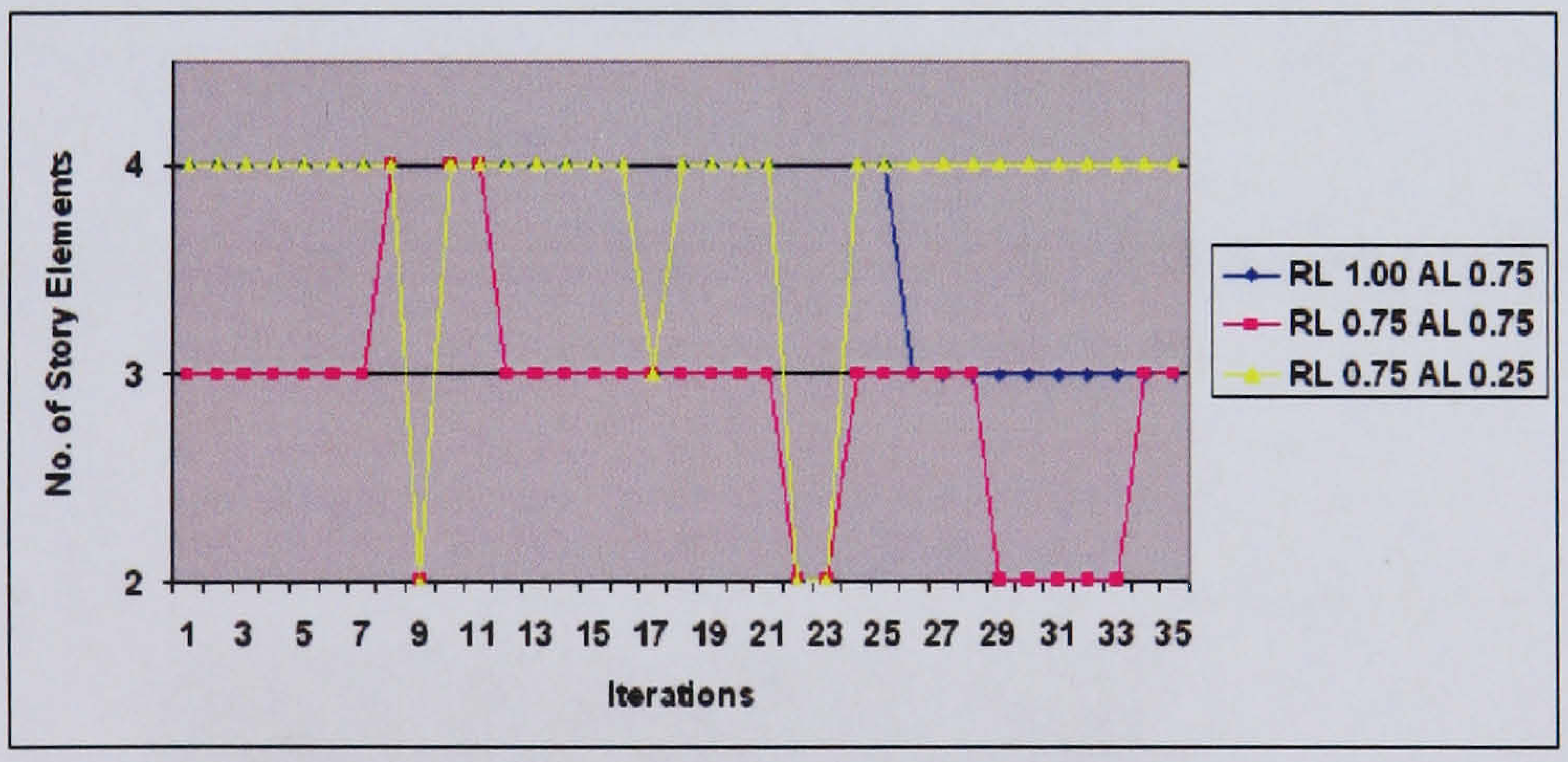


Figure 7.62: The number of stories generated by a guide for different *resolution levels*

The *resolution level,* on the other hand, affects the degree of attention that the guide applies in performing actions, and, in this case, the degree of effort put into story generation. The higher the *resolution level,* the more deliberate the guide is, hence the more elaborate the stories are. Figure 7.62 compares the number of stories generated at each iteration by a guide with a weight of 1.0 and a guide with a weight of 0.75 for its *resolution level* (*arousal* and *selection threshold* weights fixed at 0.75). Since a decrease in the weight for *arousal* increases the *resolution level*, the number of stories generated by a guide with weight 0.25 for *arousal* and 0.75 for *resolution level* is also included for comparison.

The next two figures show the influence of the *selection threshold* weight on the tendency for another intention to displace the main intention. When the *selection threshold* weight is high, it is harder for another motive to seize control, resulting in a more stable guide. Figure 7.63 shows the intention selection for a guide with a weight of 0.25 for its *selection threshold*, whilst Figure 7.64 presents the intention selection for a guide with a weight of 0.75 for its *selection threshold.*

Figure 7.63: The intention selection for a guide with weight 0.25 for *selection threshold*

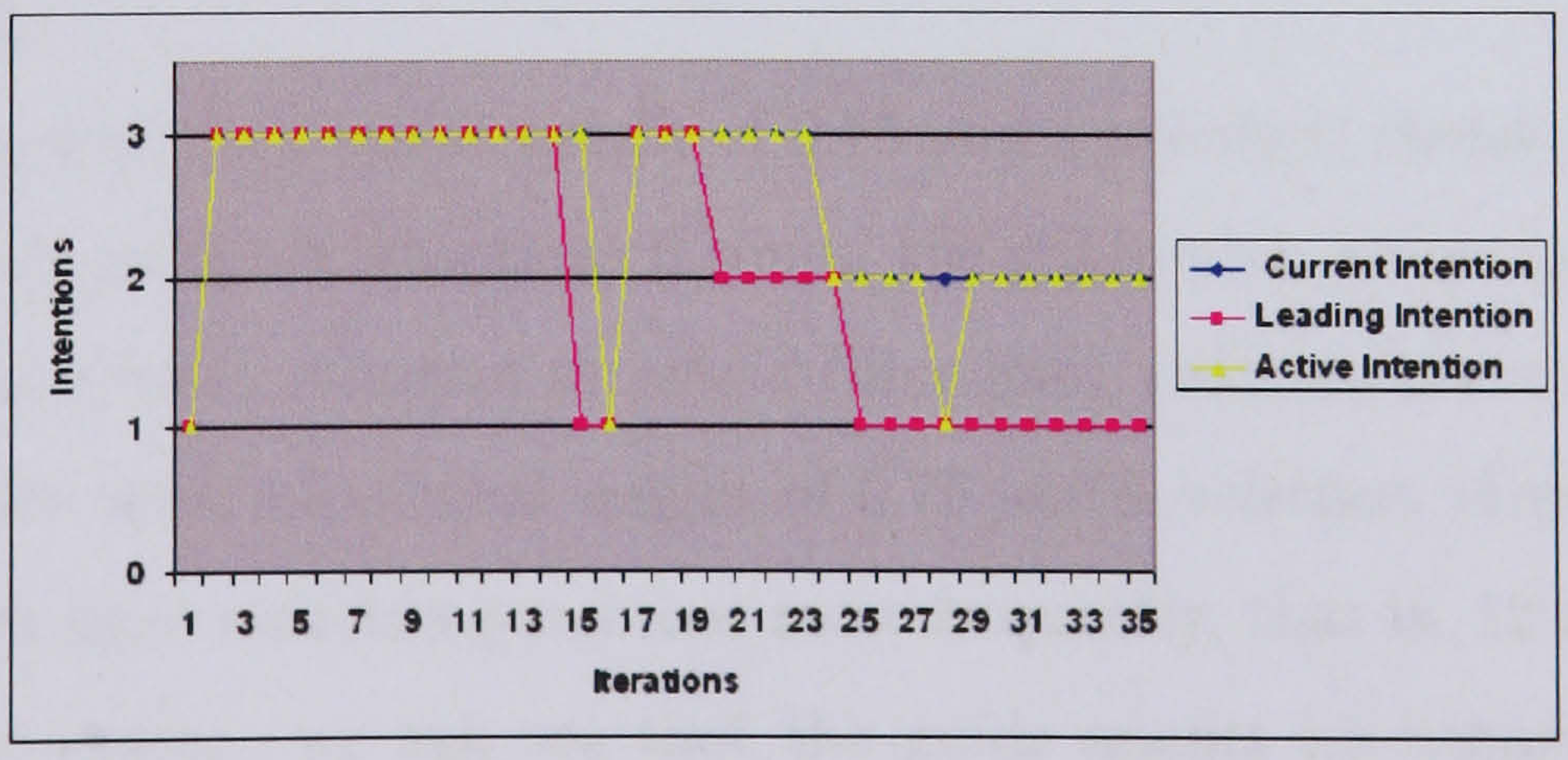


Figure 7.64: The intention selection for a guide with weight 0.75 for *selection threshold*

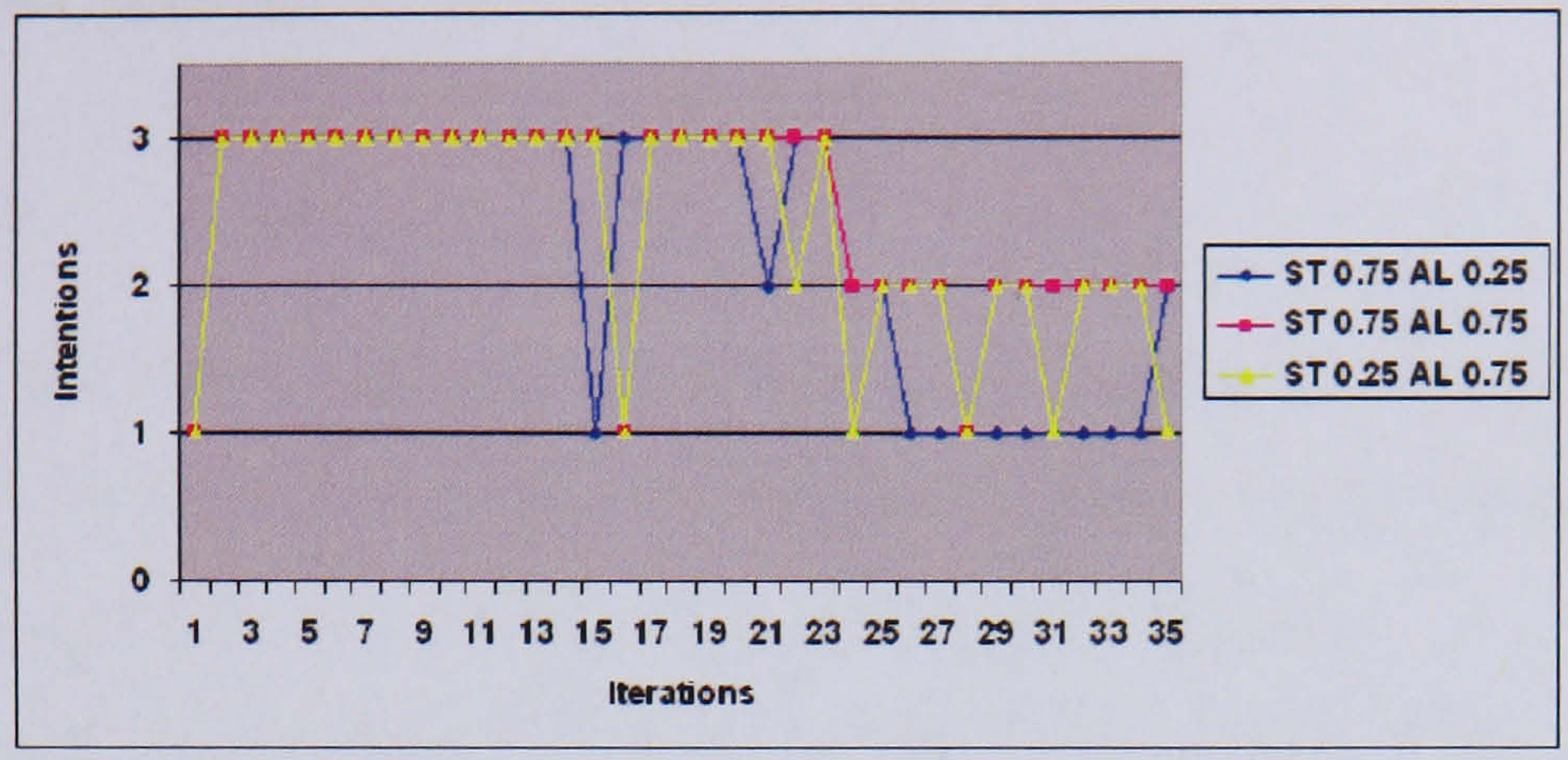


Figure 7.65: The frequency of intention switching in guides with different weight for *selection threshold*

On the graph, *Current intention* refers to the intention based on *needs* while *Leading intention* is the intention with the highest *strength* (refer to Section 6.1.3 for details). When these two intentions differ, the *Leading intention* will take control if its value is greater than the *Current intention* plus *selection threshold* value. Finally, *Active intention* is the intention that is actually selected for execution. Comparing the two graphs, it can be observed that the frequency of the *Leading intention* taking over in the guide with weight 0.25 for *selection threshold* is higher than the guide with weight 0.75 for *selection threshold.* The number of intention switching episodes in the former guide is also higher than the latter. A guide with a low *selection threshold* weight will change its intention more frequently than a guide with a high *selection threshold* weight, as illustrated in Figure 7.65.

The guide with an *arousal* weight of 0.75 and a *selection threshold* weight of 0.75 (pink line) switches intentions 6 times, the guide with an *arousal* weight of 0.25 leading to a lower *selection threshold* (blue line), switches intentions 8 times, while the guide with an *arousal* weight of 0.75 and a *selection threshold* weight of 0.25 (yellow line) switches intentions most frequently, that is, 12 times.

From this section, we can see that the guide adapts its behaviour flexibly according to the interaction environment conditions. It continuously moulds its story presentation to the users' feedback, so that the user receives a personalised tour experience.

7.2 Pilot Test

7.2.1 Aim

Five participants, four males and one female were involved in the pilot test. In this test, all connections are through a bluetooth network and the participants wore a bluetooth headset to listen to the guide's presentation.

The main aim of the pilot test was to determine whether the amount of information presented at each storytelling cycle was of an acceptable length. This is an important factor in ensuring that the user is not overloaded with too much information, hence killing their sense of enjoyment. The test also determined whether the subjective questionnaire for testing retention is too difficult. Some other features evaluated were: the ease of use of the user interface, speed for the speech system, and the character's appearance.

At this stage the performance of the guide was ignored. The participants were asked to use the system and focus on the interaction interface and story length as well as the story content. The participants were only given a brief description of device usage and no background information on the Manhattan Project was provided. They were told that the directional information would be based on the landmarks of Heriot-Watt University campus, but that the story was about the Los Alamos site of the Manhattan Project. After the interaction, they were requested to comment on all the above criteria.

To determine the feasibility of the recall questions, the participants were shown an example questionnaire. Any other critical comments on any part of the system were collected from the participants to reveal necessary refinements. The feedback from the participants is provided in Appendix F.

7.2.2 Findings and Observations

The pilot test validated the ease of use of the graphical user interface. The appearance of the guide was found acceptable, though two participants commented on the guide's baldness. They thought it made the guide look odd. However, one of the participants thought that it was the baldness that made the guide fit the story context, as it gave the guide an impression of authority.

Some flaws in the system discovered were: the speed of the speech system; the update rate of the directional arrow; text scrolling; and length of stories. 3 out of 5 participants found the speech too fast and they had difficulty understanding the guide's delivery. The update rate of the directional arrow was found to be too slow. Furthermore, they proposed display of an animated 'processing' icon while the direction is being determined rather than displaying an arrow that points in the wrong direction. A more appropriate linguistic support of navigation instructions while user is walking was also suggested to be beneficial.

It was noticed that the participants tended to scroll and listen to the stories at the same time. They expressed confusion and distraction when doing so. Therefore, they suggested an autoscroll textbox that would scroll the text to correspond to the speech. Furthermore, according to them, the reason for 'Head down' interaction is because in real life, it is natural to look at the tour guide while listening. The focus shifts to the text and guide on the screen in this system. Additionally, the text aids understanding as the speech is too fast and there is nothing much to look at on the building.

As for the stories, they found some iterations a bit too long. One reason for this is that the participants were listening to the first few chunks of stories at each location. Since it was the first time they had arrived at a location, the guide tends to introduce many new people or concepts that require further explanation, leading to a large chunk of information.

An interesting but unavoidable problem is the weather, given that the evaluation was carried out in November. The participants found it difficult to concentrate and pay attention to the guide's presentation due to the cold. The sound of the wind made the voice appear cracked and unclear. It was observed that the participants were inclined to move to the next location after at most 3 iterations of the stories. This is a serious problem because it might affect the user's perception of the guide's intelligence. The limited time does not allow the guide to do anything very intelligent and noticeable. According to participants, the reason for moving from one location to another quickly was because they had no idea how many places they would visit and how much information was available. Another reason is that they were unsure about the function of the 'More' and 'Continue' buttons.

Other comments included a request for more friendly greeting from the guide, an option for repetition of stories, inclusion of a speech recognition system, inclusion of music and a multimedia presentation of information. Finally, the participants found the subjective questions for testing recall too hard and suggested multiple choice questions or at least short questions with hints.

7.2.3 Refinements

Whilst some of the problems or suggestions can be easily solved or achieved, others would require too much effort and are not feasible in the current scope of the project. Those changes that seemed possible have been applied to the system as follows:

To improve the guide's appearance, shading was added to the guide's head to eliminate the effect of baldness. The speed of the speech system was reduced, however only slightly because this requires greater memory and processing resources, which are limited on the PDA. If the speech is slowed too much, the system runs out of resources after a while and crashes. This problem may be a problem specific to the Loquendo text-to-speech system employed. Hence, there must be a balance between these two factors. Next, the update rate of the directional arrow was increased from a 12 second to an 8 second interval. An animated 'processing' icon was also displayed, accompanied by an instruction requesting the user to start moving while the direction is being determined.

After obtaining the user's interest(s) during the greeting session, the guide gives a brief overview of the whole tour, informing the user about the total number of attractions that match their interests. The minimum number of stories available at each location is also given. This will provide the user with a rough idea about the length of the tour. To avoid confusion about the functions of the different buttons on the GUI, a detailed user manual was produced to offer instructions to the user prior to the tour.

Next, the amount of information presented at each iteration was reduced slightly. Additionally, an option to allow repetition of stories was implemented. Unfortunately, the facility for an autoscroll textbox is not supported by the smart device platform used for this application. To reduce the distraction from the weather, a wired headset was utilised instead of a bluetooth headset. Besides improving the quality of audio, it provides comfort to the user's ears from the cold. In order to encourage 'Head Up' interaction, more explicit instructions are generated to draw the user's attention to different parts of the builing during storytelling. Finally, multiple choice questions were generated for retention testing.

7.3 Full Evaluation

Two experiments were performed to establish the impact of the inclusion of emotions and attitude in the Affective Guide. Both experiments had similar settings with the only difference lying in the length of the tour, that is the participants' interaction time with the guide. We would like to determine if the addition of the emotions and attitude to the guide makes the overall tour experience more enjoyable irrespective of the tour length. In other words, whether the participants appreciate the difference between the emotional and non-emotional guide, no matter how long they interact with it. In Experiment 1, the tour took about 30-40 minutes while in Experiment 2, the tour took about 15-20 minutes, depending in both cases on the participants' chosen interest area(s) and whether they listened to all of the stories available.

7.3.1 Participants

The number of participants that took part in the experiments is shown in Table 7.5. All participants except 2 were university students or research assistants. Experience with mobile technologies ranged from moderate to very experienced with only one naive user in each of the groups. 24 out of the 40 participants in Experiment 1 had previous guided tour experience while 23 out of the 31 participants in Experiment 2 had previous guided tour experience.

Experiments	Male	Female	Total
Experiment 1	30	10	40
Experiment 2	24	7	31

Table 7.5: Number of participants in each experiment

7.3.2 Experiment Design

Three versions of the Affective Guide were tested - one emotional, one non-emotional, and one with random emotions. Because we are interested in the effect of the inclusion of emotions and attitude, we had to ensure that the only difference between the different versions of the guides was in the presence or absence of emotions and attitude. The emotional version consists of a guide that expresses its emotions through facial animation and its internal state through a colour bar. To reflect its attitude, it includes its perspective and experiences in the narration (refer to Chapter 6 for details).

van Mulken et al. [1998] found that the mere presence of an interface character makes interaction more entertaining and improves the interaction experience. In order to prevent this biasing representation effect, a guide agent also presents in a non-emotional version. The agents will be identical in both appearance and vocal qualities. The only distinguishing factor is that the non-emotional agent does not change its facial expression nor the colour on the colour bar. The non-emotional version consists of a guide with a neutral emotional state, achieved by fixing the values of the modulating parameters. Its processing and internal state are not affected by user feedback and it does not present any perspective related stories. Additionally, in order to verify that it is not the facial expressions of the guide alone that causes the guide to be perceived as more interesting, a variation of the non-emotional version is included where the non-emotional guide generates random facial expressions and changes the colour on the colour bar randomly.

To consider the effect of the inclusion of attitude, a basic set of facts common to all versions of the guide is incorporated. During the interaction, the emotional guide will adjust its narrative generation based on its internal state. If its *resolution level* is high enough, it will present its personal experience on, and view of the subject of discussion. In this case, emotional story elements will be combined with the neutral story elements, hence providing a more elaborate story. Since for the non-emotional guide there is no perspective information, there is an issue of a systematic difference in the story length. It might be the case that shorter stories from the non-emotional guide itself make the stories more or less interesting. In order to overcome this problem, the description associated with concepts has been extended in the non-emotional version. A slightly longer version of the personnel descriptions is also provided for the non-emotional version, although care has to be taken to ensure that the information is as neutral as possible, so that the only differences between the performances of both guides are precisely those due to the addition of the guide emotions and attitude.

Hence, the three versions for the guide are:

- Guide A: The guide shows emotions and attitude
- Guide B: The guide shows neither emotions nor attitude (the control group)
- Guide C: The guide shows emotions but no attitude (the placebo group)

Furthermore, we would like to determine if Guide A is better able to foster learning in the user. Are users more motivated to learn about the subject when the presentation is made by a guide with attitude? Does a guide with attitude embody a higher level of intelligence that prolongs the participant's attention? Does the perspective information help the user to think over the subject and improve their understanding? Does the inclusion of perspective and life experience make the stories more interesting? The goal is to verify if the emotional guide with attitude is able to create a greater long term memory effect in the user compared to the non-emotional guide and the random emotions guide. It also helps to determine if the user is affected by the guide's viewpoint in any way and if s/he is able to combine the information s/he received with her/his own opinion to arrive at a conclusion about a particular subject. The possible results of this study are:

- Guide A increases comprehension/recall performance, possibly because of an increase in the user's motivation
- Guide A decreases performance in comprehension and recall, possibly because it attracts the user's attention to itself, and thus away from the relevant information
- Neither decreases nor increases comprehension and recall, possibly because neither of the above mentioned effects exist or possibly because the respective effects are equally strong and thus acting as antagonistic factors which prevent any effect on comprehension and recall from being observed

7.3.3 Procedure

In the experiments, the participants were asked to interact with the virtual guide, a member of military personnel who supports the development and employment of the atomic bomb. Prior to the tour, the participants were required to answer some general questions about their previous experience with mobile technologies and guided tours, as well as their interest in the topic of presentation (Section G.1 of Appendix G). The participants were not told the purpose of the experiments, hence, they cannot predict, and will not be affected by, any prior assumptions about the guide's behaviour. Random assignment was adopted where participants were asked to draw a paper with the guide's name from a box, to ensure that subject variables such as intelligence and personality were more evenly distributed across treatments, reducing selection bias.

The participants were provided with instructions for use as well as background information about the Manhattan Project and were told that they would be tested on their knowledge about the Los Alamos site after the tour. Then, the guide took each participant around the Heriot-Watt University campus which acted as the

Los Alamos site, telling stories about the Manhattan Project. The participants can choose one of three areas - Science, Military or Social as their interest for the guide's narration. To prevent distraction, the participant is allowed to carry the PDA and laptop and conduct the tour alone. Based on observations from the pilot test, the weather conditions under which the participant took the tour was recorded so that its impact on the tour experience can be determined.

Participants were requested to listen to at least three stories at each location. During the tour, participants are required to give their opinion about their degree of interest in the stories, as well as how much they agreed with the guide's argument after each storytelling cycle. This step was performed by all participants, including those interacting with the non-emotional and random emotions guide. For these two groups, the participants' input did not affect the processing of the guide in any way, but acted as a control and gave the participants the impression that the guide was reacting to their feedback. Upon completion of the tour, each participant was asked to answer two sets of questionnaires.

7.3.4 Questionnaires

In both experiments, the independent variables (IVs) are the Affective Guide's emotions and attitude (absence or presence); and the story domain. We defined as the dependent variables (DVs), the guide's storytelling performance, the guide's facial expressiveness, the guide's character, the participants' tour experience and their performance on the recall test.

Questionnaire A (Section G.2 of Appendix G) measured the first four DVs using a 7-point, Likert scale, to establish any differences in acceptance depending on the type of guide. A rating of 1 indicated the worst or a negative answer, while 7 indicated the best or a positive answer. Five questions assessed the guide's storytelling performance (Q1:intelligence, Q2:believability, Q3:emotional content, Q4:interest relation, Q5:stories adjustment); five questions assessed the guide's facial expressiveness (Q6:intelligence, Q7:believability, Q8:naturalness, Q9:emotional reaction, Q10:appropriateness); two questions assessed the guide's character (Q11:personality, Q12:resemblance to real guide) and four questions assessed the participant's experience (Q13:interestingness, Q14:meaningfulness, Q15:engagement, Q16:overall experience).

In addition to the Likert scale, short answers were required for questions regarding the guide's facial expression and character, in order to obtain the participant's subjective opinions. They were requested to list the perceived emotions and describe the guide's personality in their own words. Participants were also asked to indicate whether they found the amount of information overwhelming (Q17), so as to avoid the subjects' answer to the retention questionnaire being confounded by lack of interest and information overload. The interaction interface (Q18:ease of use, Q19:comfort, Q20:compellingness) was evaluated to ensure that it was not a disruptive factor in the participants' experience. Finally, the participants were requested to give comments and suggestions about the whole system.

Questionnaire B was applied right after the tour to test recall level. The first part contained multiple choice questions based on what the participants had listened to during the tour. The second part contained short subjective questions to extract participants' opinions concerning the guide's arguments about controversial issues on the topic. This part only applies if the guide did make arguments (Guide A) but all participants are requested to complete it. This helps to determine if the subject is affected by the guide's viewpoint in any way and if s/he is able to combine the information s/he received with her/his own opinion to arrive at a conclusion about the issue. Subjects could take as long as necessary to complete the test. Each correct answer for the multiple choice questions was awarded one point. The sample multiple choice questionnaire and the subjective questions questionnaire are presented in Section G.3 of Appendix G

7.3.5 Statistical Analysis

Due to some technical problems the results for one participant from each experiment had to be discarded, making a total of 39 participants in Experiment 1, 13 participants (10 males, 3 females) and a total of 30 participants for Experiment 2, 10 participants (8 males, 2 females) for each guide. For each experiment, a one-way Multivariate Analyses of Variance (MANOVA) was performed to examine the effect of the different guides on linear combination of the DVs. Additionally, a separate MANOVA was applied to see the impact of the different story domains on the DVs. MANOVA protects against inflated Type I error due to multiple tests of (likely) correlated DVs over a series of Univariate Analyses of Variance (ANOVA) [Tabachnick and Fidell, 2001].

A significant omnibus F-test in MANOVA only tells that the means between groups are not equal for the DV. Post-hoc tests which look at possible pairwise or all possible pairwise and otherwise comparisons are necessary to know exactly which means are significantly different from which other ones. Since the ordering of the DVs is somewhat arbitrary, ANOVAs with Bonferroni adjustment (overall $\alpha < 0.05$) instead of Roy-Bargmann stepdown analysis were employed for follow-up analyses on those DVs that showed significance in the omnibus F-test. The Bonferroni tests are reported by giving the mean difference in the DV between any two groups. For the analysis of guides, A, B and C represented the observed means for Guide A, Guide B and Guide C respectively. In the analysis of story domains, C, M and S represented the observed means for 'Science', 'Military' and 'Social' respectively.

7.3.6 Experiment 1

Results

The MANOVA for Experiment 1 was significant with Wilks' Lambda=0.088, F=2.023 and P=0.019. The result showed a reasonably high association between guides and the combined DVs with partial η^2=0.704. Figure 7.66 compares participants' rating for Guide A, B and C. The omnibus F-test showed a significant difference for believability of storytelling ($F(2, 36)=3.708$, $P<0.05$) and emotional rating of facial expressions ($F(2, 36)=11.78$, $P<0.001$). Table 7.6 lists the mean (standard deviation) for the significant DVs.

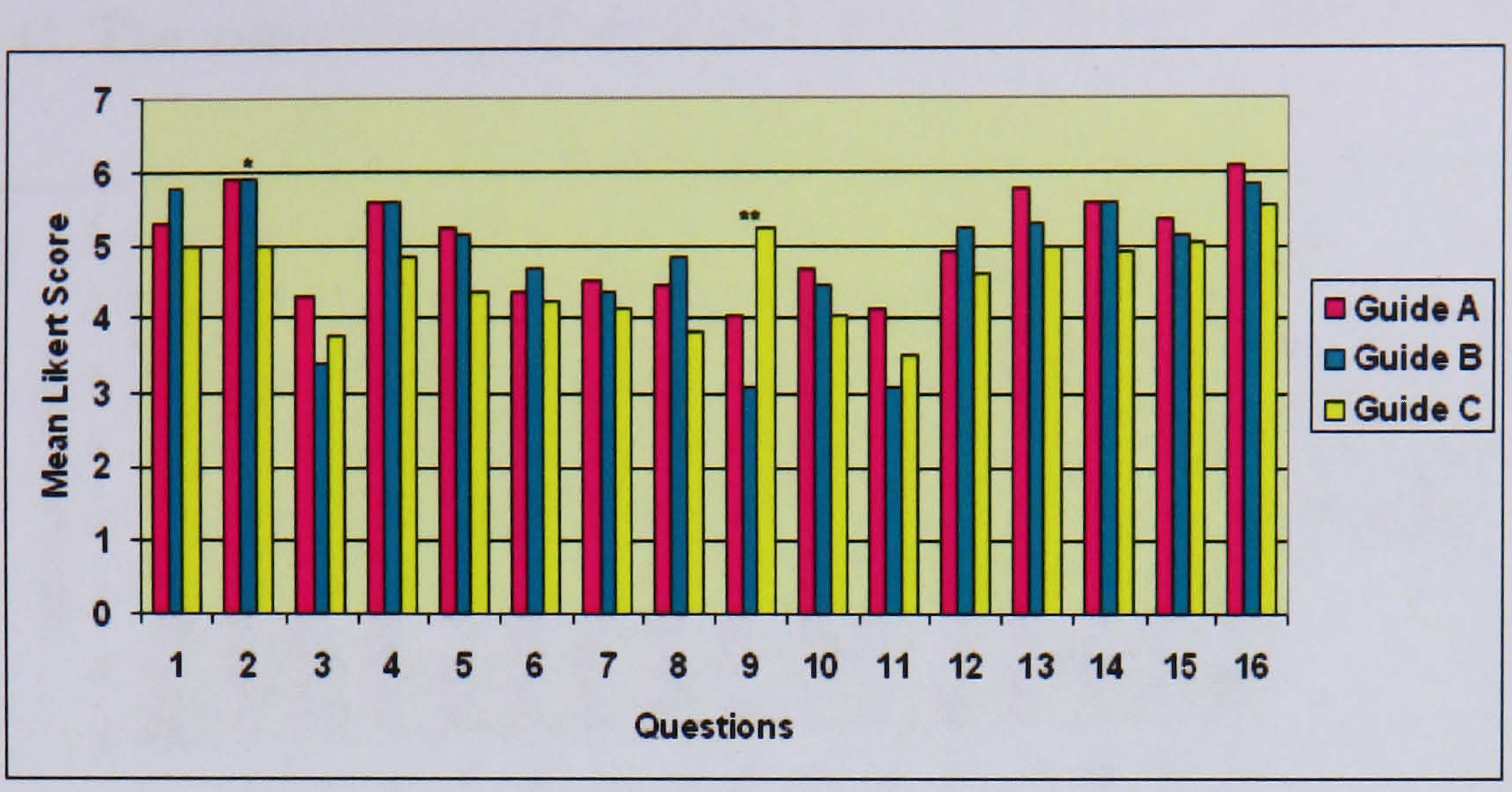


Figure 7.66: Significant differences in rating between Guide A, B and C (* P<0.05, ** P<0.001)

DV	Guide A (n=13)	Guide B (n=13)	Guide C (n=13)
Storytelling performance:			
Q2:believability	5.92 (.760)	5.92 (.641)	5.00 (1.414)
Facial expressiveness:			
Q9:emotional reaction	4.08 (1.188)	3.08 (1.038)	5.23 (1.166)

Table 7.6: Mean and standard deviation for significant DVs in Experiment 1

The post-hoc ANOVA showed no significant difference between Guide A and Guide B. Meanwhile, the analysis for Guide A and Guide C revealed that Guide C is significantly more emotional than Guide A (C-A=1.15, $P<0.05$). For comparison between Guide B and Guide C, participants found Guide C's facial expressions significantly more emotional than Guide B's (C-B=2.15, $P<0.001$).

A separate MANOVA was performed taking male participants only. Significant differences were found across DVs, with Wilks' lambda=0.011, F=3.463 and P=0.005. A high association between guides and the combined DVs was observed with partial η^2=0.895. The overall F-test indicated significant difference in intelligence of storytelling ($F(2, 27)=4.192$, $P<0.05$), believability of storytelling ($F(2, 27)=3.498$, $P<0.05$), stories adjustment ($F(2, 27)=4.314$, $P<0.025$), naturalness of facial expressions ($F(2, 27)=4.776$, $P<0.025$), emotional rating of facial expressions ($F(2, 27)=8.830$, $P<0.025$) and overall tour experience ($F(2, 27)=4.500$, $P<0.025$). Figure 7.67 compares male participants' rating for Guide

A, B and C. The mean (standard deviation) for the DVs are shown in Table 7.7.

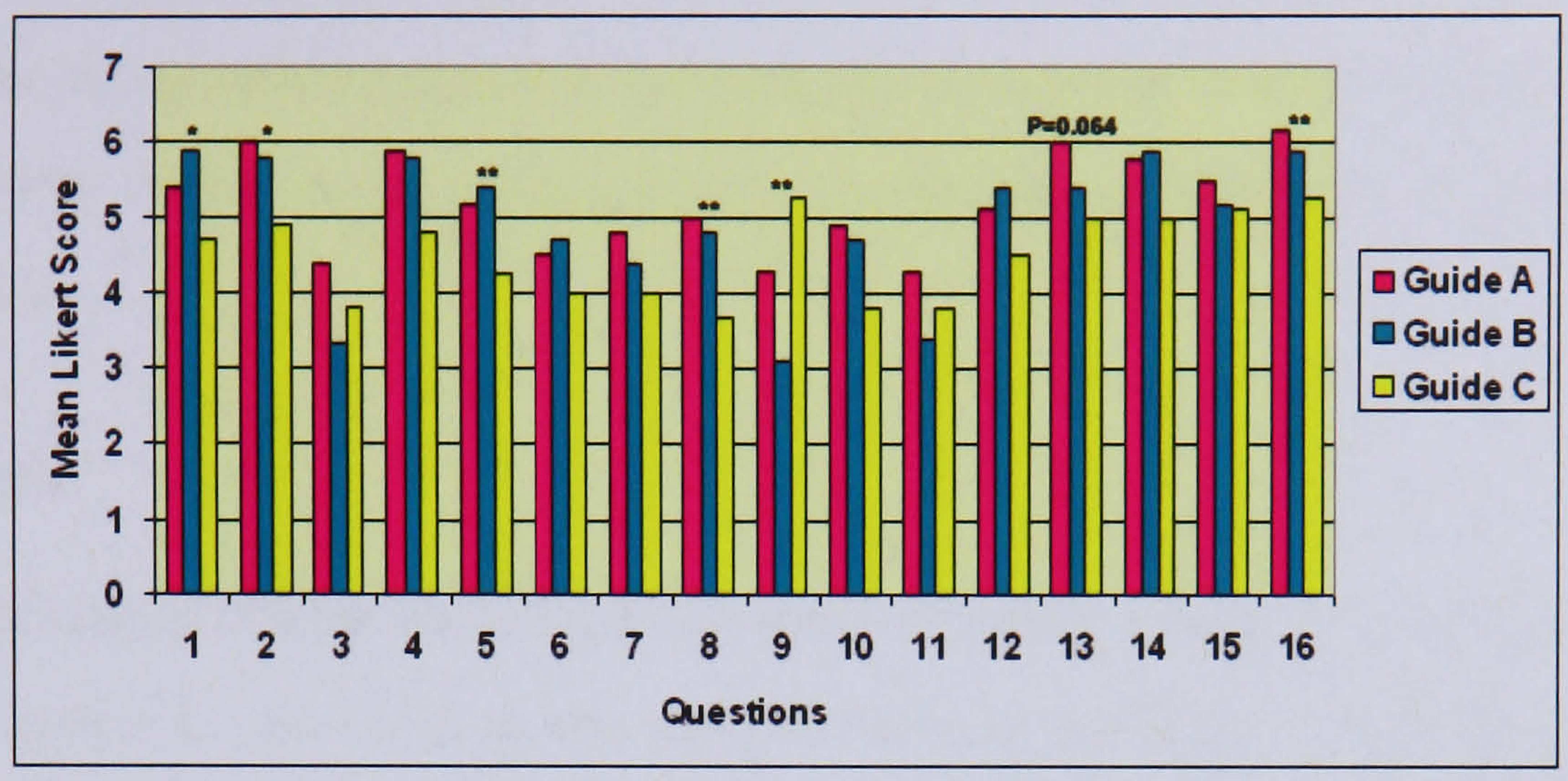


Figure 7.67: Significant differences in rating between Guide A, B and C for male participants (* P<0.05, ** P<0.025)

DV	**Guide A (n=10)**	**Guide B (n=10)**	**Guide C (n=10)**
Storytelling performance:			
Q1:intelligence	5.40 (.699)	5.90 (.876)	4.70 (1.160)
Q2:believability	6.00 (.667)	5.80 (.632)	4.90 (1.449)
Q5:stories adjustment	5.20 (1.135)	5.40 (.843)	4.25 (.791)
Facial expressiveness:			
Q8:naturalness	5.00 (1.054)	4.80 (.919)	3.70 (1.059)
Q9:emotional reaction	4.30 (1.160)	3.10 (1.101)	5.30 (1.252)
Participant's experience			
Q16:overall experience	6.20 (.632)	5.90 (.568)	5.30 (.823)

Table 7.7: Mean and standard deviation for significant DVs in Experiment 1 for male participants only

In the Bonferroni test, no significant effect was detected for Guide A and Guide B. Comparing Guide A and Guide C, participants observed Guide A's facial expressions to be more natural than Guide C's (A-C=1.30, P<0.025). Overall, participants who interact with Guide A had a significantly better experience than those who interacted with Guide C (A-C=0.90, P<0.025). Comparing Guide B and Guide C, male participants found Guide B's discourse more intelligent (B-C=1.20, P<0.025) and its capability in adjusting the story significantly better than Guide C's (B-C=1.15, P<0.05). In terms of facial expressions, Guide C is significantly more emotional than Guide B (C-B=2.20, P<0.025). Guide B and Guide C do not differ in terms of participant's experience.

Finally, the average score for the whole group in recall test for Guide A is 55.38, Guide B is 51.00 and Guide C is 54.80. The average mark for male participants only in the recall test for Guide A is 54.46, Guide B is 50.49 and Guide C is 51.89. These scores are all in percentages and no significant difference is detected for this variable.

Discussion

The whole group results show that in terms of facial expressions (Q9), a random emotions guide is perceived as the most emotional, followed by a guide with normal emotions and lastly the non-emotional guide. However, the emotional level for the facial expressions between the emotional guide and the non-emotional guide does not differ significantly. The gradual changes in the emotional guide would explain this because these slight changes might not always have a noticeable effect. Moreover, the facial expressions were only visible for a short period of time when the guide was waiting for the participants' input. Since the participants were busy rating the guide's discourse, they might not have paid attention to its facial expressions. These issues were raised in the questionnaire, a few participants suggested for more obvious and a longer display of the guide's facial expressions.

The average rating for the emotional guide is slightly more than 4 on the Likert scale, which suggests that the guide is expressing emotions at the right level, not too much or too little. The emotions detected by the participants who interacted with the emotional guide are happiness, anger, eagernesss, surprise, neutral, boredom, smile, joy and annoyance. The random emotions guide's rating on the other hand is above neutral, more than 5, while the non-emotional guide's rating falls below neutral, slightly above 3. Two of the participants that interacted with the non-emotional guide labelled the guide's emotion as sorrow and contentment respectively, while others observed no emotional expressions.

The facial expressions of the random emotions guide can change quite drastically which explains why it is the most emotional. Participants detected sadness, anger, joy, disappointment, grin, happiness, tiredness, impatient, worried, frown, concerned and anxiousness in the guide. Nevertheless, the participants did not perceive the randomness in facial expressions as inappropriate (Q10). This could be due to the fact that the guide was generating the right emotion at some points and the wrong emotion at others, cancelling out the effect of inappropriateness. Participants may also be applying different standards regarding appropriateness of expressions and may view the inappropriate emotions as the guide's sense of humor, as one of them stated in the questionnaire. Despite the fact that participants did not find the guide's expressions inappropriate, its random behaviour is a reaction to something other than their input, and it is represented by a marked divergence from expected behaviour. They thought that the guide was too emotional and its reactions confusing.

Although the believability of the stories (Q2) did not show significant effect between guides, it can be observed from Figure 7.66 and Figure 7.67 that the participants who interacted with the emotional guide and non-emotional guide gave a higher rating for this variable than those who interacted with the random emotions guide. The consistency of expressions in the non-emotional guide could have made it more trustworthy. In addition, most of the participants in these two groups selected 'Science' and 'Military' compared to 'Social' as their interest and this might also explain why they believe the non-emotional guide more than the random emotions guide, as scientists and military personnel are usually quite serious.

Overall, no significant difference is detected for the whole group omnibus F-test for the guide's intelligence in storytelling (Q1). One reason that the reported differences between guides did not achieve significance may have been due to the granularity of the rating scale employed in the experiment. Participants tend to rate the guide's storytelling capability highly because of its vast knowledge on the subject, as most of them have little or no knowledge at all before they took the tour. Using a 7 point Likert scale meant that there was proportionally little room to express any further improvements.

The degree of emotional content in the stories (Q3) recorded no significant difference. This may be due to the fact that the topic is a serious one, though from the graph in Figure 7.66 and Figure 7.67 we can see that the stories presented by the emotional guide were given a higher emotional rating. Additionally, changes in voice tone are important for emotional detection, and the text-to-speech system used lacked this. Next, the participants found the stories related to their chosen interest (Q4) resulting in no significant difference between the groups. All the spots of attraction were chosen based on the participant's selected interest during the start of the tour, which may also explain why no significant difference was observed for story adjustment based on feedback (Q5). The already high relation between stories and interests caused participants to show high interest in the stories most of the time. As a result, only a slight adjustment to the stories was performed by the emotional guide during the tour making the effect less noticeable.

The result showing insignificant differences for the intelligence of the guide's appearance (Q6), maybe a judgment based on first impressions rather than interaction behaviour. Furthermore, the appearance of the guide is constant across conditions. In this experiment, facial expression changes were the same for all guides except in the intensity of changes, leading to equivalent degrees of believability (Q7) and naturalness (Q8) for the guide's facial expressions. The personality (Q11) comparison between the guides did not differ significantly but observing Figure 7.66 and Figure 7.67 again, the emotional guide's participants expressed higher ability in identifying the guide's personality. The inclusion of attitude might have made the guide character's more distinctive. The emotional guide is being described as interesting, helpful, funny, friendly, hardworking, opinionated towards others, enthusiastic, happy, accurate, patriotic, loyal, sociable, outspoken, confident, cautious, reactive, patient, open-minded, straighforward and frank. In contrast, the non-emotional guide is being described as calm, intelligent, informative, serious, friendly, confident, trustworthy, giving, sad and knowledgeable. Participants described the random emotions guide as sad, unenthusiastic, proud, susceptible, expressive, bitter, sad, angry, unbiased, flat, observant, intelligent, sharp, shrewd and not friendly.

Each guide was given an average rating of about 5 for the degree of resemblance to its real counterpart (Q12). The participants judged the guide's resemblance based on the guide's knowledge about the subject, information presentation and the navigation instructions. Notwithstanding, participants who interacted with the emotional guide commented on the guide's emotional responses and ability to present stories and anecdotal information rather than just facts as reminiscent of a real guide.

In terms of tour experience (Q13-Q16), the participants did not show any significant preference. Participants who interacted with the non-emotional guide may have found the guide more believable but lacking in friendliness. In contrast, those who interacted with the random emotions guide found the guide humorous, making the interaction more interesting but doubted its capability. As for the emotional guide, although the omnibus F-test for the whole group did not reflect a high enough degree of significance for tour experience (Q16), the omnibus F-test for male subjects alone did. The male participants who interacted with the emotional guide had a better overall tour experience than those who interacted with the random emotions guide. Female subjects seemed to enjoy the tour less due to the topic of the tour, which they found boring and mentally taxing. They may have paid less attention to the guides and the overall interaction process which would explain why the test on the whole group was less significant across DVs. Nevertheless, from the figures, it can be observed that the emotional guide has a higher rating for Q13, Q15 and Q16, followed by the non-emotional guide and finally the random emotions guide.

Consistent with the overall results, the male participants rated the random emotions guide as highest in emotional expressiveness (Q9), followed by the normal emotions guide and finally the non-emotional guide. Since the emotional guide is showing emotions at the right level, it is perceived as more natural (Q8) than the random emotions guide. Although the non-emotional guide did not show any emotion, at least it did not show emotions that contradicted its supposed emotional state. As a consequence, male participants also rated the non-emotional guide's facial expressions as more natural (Q8) than the random emotions guide.

This would also explain why they perceived the non-emotional guide discourse as more intelligent (Q1) than those presented by the random emotions guide. As for the participants' perceptions of the guide's ability to adjust stories (Q5) in these two groups, this could be solely an influence of the questionnaire. The participants might not have any clue whether the guide is adjusting the stories or not but because they were being asked to rate how well the guide adjusts stories based on their feedback, they interpret that the guide must have done so.

In all cases, the usability of the interaction interface was rated highly. Therefore, it should not have impacted participants' tour experience. The most general problem faced by the participants was with the navigation system, when the GPS was slow in detecting the location due to clouds. However, participants who took the tour when the sky was clear found the navigation system, especially the directional arrow helpful, and suggested it was one of the best features of the system. Other comments on the best part of the system are the stories, the availability of speech with text as complement, the simple user interface, freedom to explore at will, matching of stories and location, automatic location detection and storytelling, personalisation of greeting and the talking head. On top of that, those who interacted with the emotional guide liked the sense of having a companion capable of tailoring the stories to their interests.

The most desirable change would be the voice of the guide. Most participants had problems keeping up with the guide's discourse due to the less-than-natural and high speed voice generated by the text-to-speech system. This would explain why most participants reported an overload of information because they lost track of the guide's discourse easily. This could also be the reason for insignificant differences in the meaningfulness (Q14) of the tour. Generally, the meaningfulness of tour was given a rating above 5 in all the conditions. As requested in the pilot test, many of the participants in the full evaluation also recommended an autoscroll textbox. They also recommended a map or pictures of buildings to be included to increase the reliability of the navigation system. Some suggested an interface with fewer clicks or touches, which would call for the use of biometric devices to detect the user's emotional states. Please refer to Appendix H for the complete feedback on the systems.

As for the recall test, no significant difference was observed. The guide's voice would be an obvious cause. Many of the participants were non-native English speakers which further complicated the comprehension of information. Tests were carried out in November-December and the Scottish cold winter is another factor which reduced participants' concentration levels, as many of them pointed out. The availability of multiple choice in the recall test would have also allowed the participants to guess the answer when they were unsure. Additionally, the number of questions that each participant had to answer varied, depending on the amount of stories they listened to. As a result, performance may also vary with participants that answered fewer questions scoring better than those with more questions. Another reason would be that the participants took the test right after the tour without any delay period. According to Cox et al. [1999], no positive learning effects will be found if recall test is carried out too soon following an experiment.

With regard to the participants' judgment of the guide's arguments, 9 out of the 13 participants who interacted with the emotional guide expressed their agreement or disagreement and viewpoints. Although these results are inconclusive, the inclusion of attitude in the guide does have some influence on the participants' answers to the subjective questions. A full list of the participants' subjective response is available in Appendix H.

7.3.7 Experiment 2

Result

In Experiment 2, the MANOVA was insignificant whereas some of the DVs showed significant F values. According to Tabachnick and Fidell [2001], about the best one can do in such a case is to report the nonsignificant multivariate F and offer the univariate results as a guide to future research. The MANOVA gave Wilks' Lambda=0.037, F=1.673, P=0.133 and partial η^2= 0.807. The omnibus F-test showed significant results for emotional rating of facial expression (F(2, 27)=4.059, P<0.05), personality (F(2, 27)=4.693, P<0.025) and engagement (F(2, 27)=5.250, P<0.025). Figure 7.68 shows the comparison between Guide A, Guide B and Guide C whereas Table 7.8 lists the mean (standard deviation) for those DVs that are significant in the omnibus F-test.

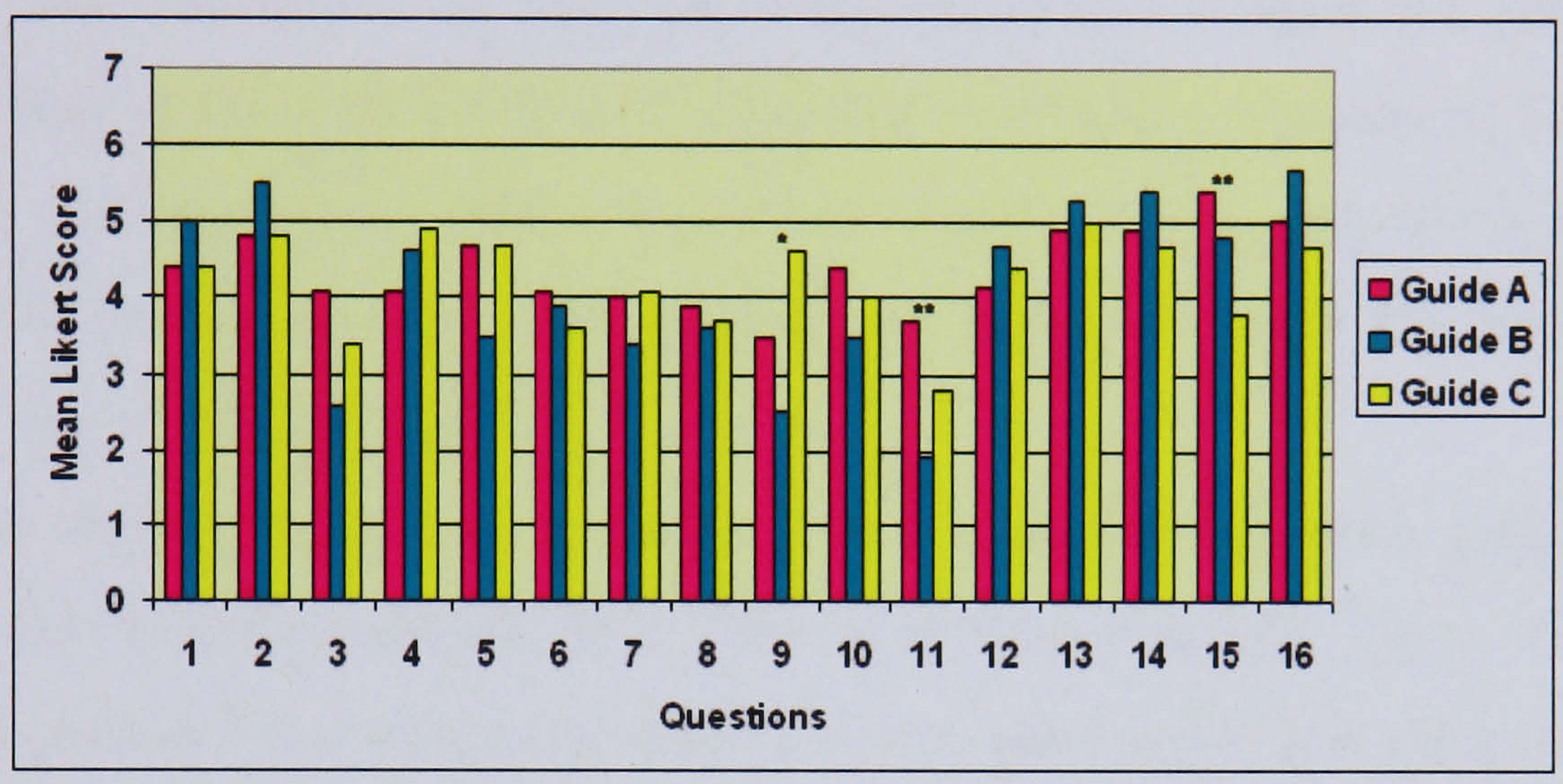


Figure 7.68: Significant differences in rating between Guide A, B and C (* P<0.05, ** P<0.025)

DV	Guide A (n=10)	Guide B (n=10)	Guide C (n=10)
Facial expressiveness:			
Q9:emotional reaction	3.50 (1.269)	2.50 (2.014)	4.60 (1.578)
Guide's character			
Q11:personality	3.70 (1.567)	1.90 (.994)	2.80 (1.317)
Participant's experience			
Q15:engagement	5.40 (1.174)	4.80 (1.033)	3.80 (1.269)

Table 7.8: Mean and standard deviation for significant DVs in Experiment 2

The Bonferonni test showed that Guide C is perceived as more emotional than Guide B (C-B=2.10, P<0.05) and the participants expressed higher capability in predicting Guide A's personality than Guide B's (A-B=1.80, P<0.025). Besides that, Guide A is perceived as more engaging than Guide C (A-C=1.60, P<0.025). As for the recall test, again, no significant difference is observed. The average percentage score for Guide A is 57.64, Guide B is 47.11 and Guide C is 56.42.

Discussion

Experiment 2 aimed at examining whether a shorter interaction time has an impact on the participants' perception of the guide and their tour experience. From the results above, it appears that this may be the case. No significant difference was detected in the MANOVA test and only two significant differences were detected in the omnibus F-test. From the standard deviations in Table 7.8, it can be observed that a higher variation exists in the rating of Experiment 2 compared to Experiment 1 (Please refer to Appendix H for the means and standard deviations for all DVs).

Reasserting the findings of Experiment 1, the random emotions guide is perceived as more emotional (Q9) than the non-emotional guide. Again, the emotional comparison between the emotional and non-emotional guide did not achieve significance. On the other hand, participants thought that they could predict the personality (Q11) of the emotional guide better than that of the non-emotional guide, confirming that the inclusion of attitude does make the guide character's more distinctive. Whilst this difference was not detected in Experiment 1, it could be explained by the short interaction time. Since the non-emotional guide does not show any response in term of facial expression, and the participants only had the opportunity to listen to a few stories, they might hold a neutral judgment. The missing emotional reaction reinforced the difficulty of making any assumption about the guide's personality. When interaction time increases and as participants listened to more presentations, they might have detected some reflection of personality, possibly because the information presented by the non-emotional guide, particularly for personnel description, was not neutral enough. Additionally, according to Oberlander and Gill [2006], all text has personality, which explains why hearing more of it - even if "non-perspectival" gives more of an impression of personality. The personality comparison between the emotional and random emotions guides did not differ significantly. This could be explained by the randomness of expressions that led the participants to perceive some kind of personality in the random emotions guide.

The participants who interacted with the emotional guide rated it as more engaging (Q15) than those who interacted with the random emotions guide, confirming our inference in Experiment 1. This could be due to the fact that the inclusion of attitude in the guide causes its stories to be more realistic and absorbing. On the other hand, the randomness of the emotions expressed by the random emotions guide may have distracted the participants' engagement. Surprisingly, for Q13, Q14 and Q16, there is a preference, though not substantial, in the direction of the non-emotional guide, contradicting the findings of Experiment 1. The participants may simply not notice an improved performance in the emotional guide to a significant enough degree due to the short interaction time. As in human social interaction, it takes time to know an individual personally. The result of the recall test is again inconclusive. The same observation as in Experiment 1 is obtained for participants' comments on the guide's arguments. Please refer to Appendix H for a complete list of the participants' response.

7.3.8 Combination test

Since we are interested in whether the impact of the guide's emotions and attitude on tour experience is related to interaction time, a 2 x 3 MANOVA was conducted with Experiment (length of tour) and Guide as IVs, the 20 DVs remained the same. The result showed a significant effect for the Guide across DVs (Wilks' Lambda=0.198, F=2.741, $P<0.001$ and partial η^2=0.555). However, no significant effects were found for either Experiment (Wilks' Lambda=0.609, F=1.415, P=0.167 and partial η^2=0.220) or the interaction between Experiment and Guide (Wilks' Lambda=0.412, F=1.227, P=0.213 and partial η^2=0.358) on the linear combination of all DVs.

The omnibus F-test for Guide detected significant differences in emotional content of the stories ($F(2, 63)=3.792$, $P<0.05$), emotional rating of facial expressions ($F(2, 63)=13.490$, $P<0.001$), personality ($F(2, 63)=6.928$, $P<0.025$), engagement ($F(2, 63)=4.841$, $P<0.025$) and overall tour experience ($F(2, 63)=3.359$, $P<0.05$). Figure 7.69 shows the DVs comparisons for Guide in the omnibus F-test while

Table 7.9 presents the means (standard deviations) of the significant DVs for post-hoc test.

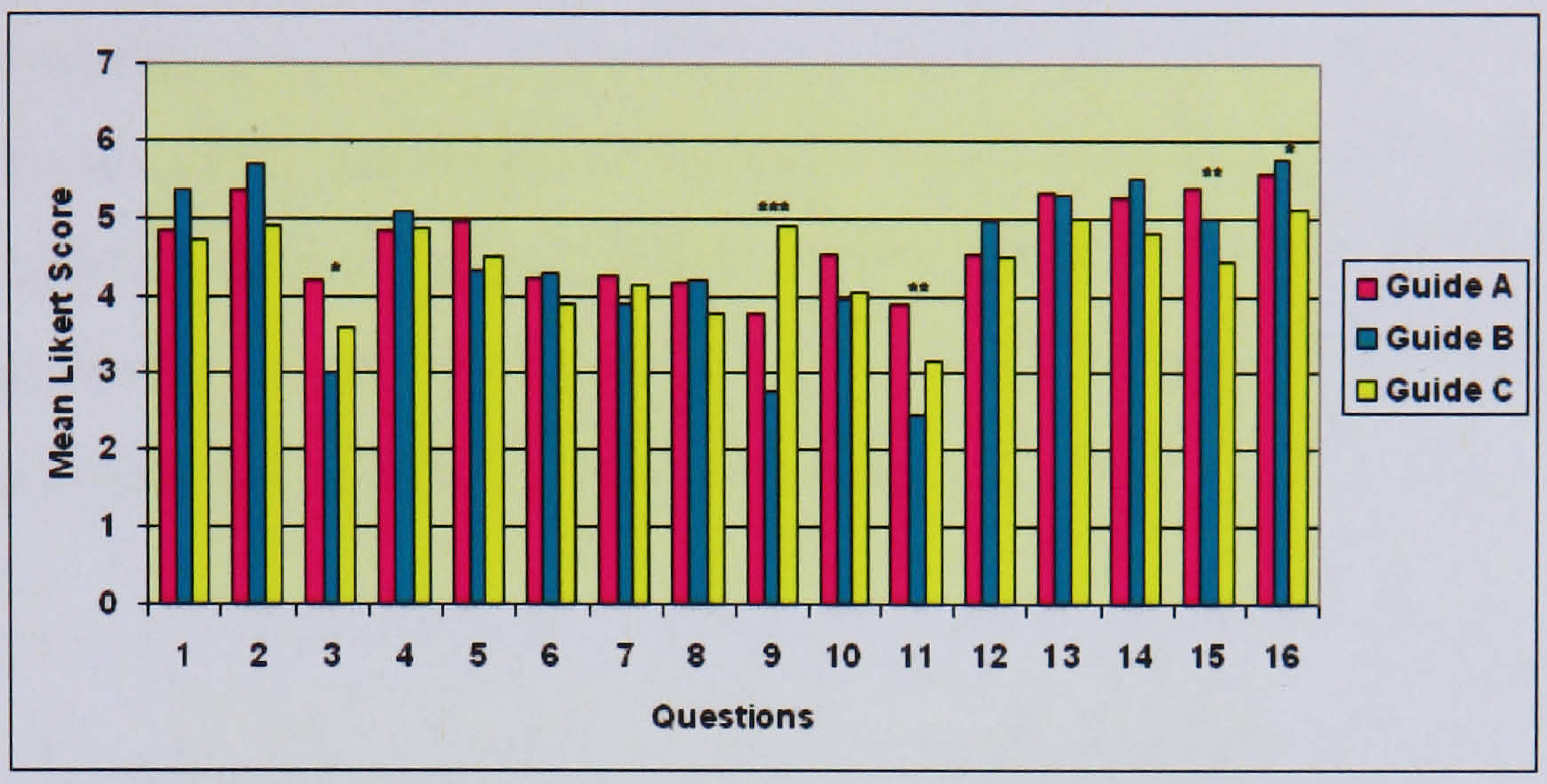


Figure 7.69: Significant differences in rating between Guide A, B and C (* P<0.05, ** P<0.025, *** P<0.001)

DV	Guide A (n=23)	Guide B (n=23)	Guide C (n=23)
Storytelling performance:			
Q3:emotional content	4.22 (1.278)	3.04 (1.581)	3.61 (1.530)
Facial expressiveness:			
Q9:emotional reaction	3.83 (1.230)	2.83 (1.527)	4.96 (1.364)
Guide's character:			
Q11:personality	3.96 (1.364)	2.57 (1.308)	3.22 (1.347)
Participant's experience			
Q15:engagement	5.39 (1.033)	5.00 (.953)	4.52 (1.238)
Q16:overall experience	5.63 (.907)	5.78 (.850)	5.17 (1.029)

Table 7.9: The significant DVs' means and standard deviations for Guide

Comparing Guide A and Guide B, the stories presented by Guide A were found to be significantly more emotional than those presented by Guide B (A-B=1.18, P<0.05). In terms of facial expressions and character, Guide A was more emotional than Guide B (A-B=1.00, P=0.05) and the participants were better able to predict Guide A's personality than Guide B's (A-B=1.39, P<0.025). Meanwhile, analysis of Guide A and Guide C showed that Guide C was more emotional than Guide A (C-A=1.13, P<0.025) but Guide A was more engaging than Guide C (A-C=0.87, P<0.025). On the other hand, Guide C is significantly more emotional than Guide B (C-B=2.13, P<0.001).

Figure 7.70 shows the DVs comparisons for Experiment as IV. Although the MANOVA did not show significant effects in length of tour across DVs, the omnibus F-test found many significant differences: intelligence of storytelling ($F(1, 63)=8.806$, $P<0.025$), believability of stories ($F(1, 63)=4.667$, $P<0.05$), interest relation ($F(1, 63)=7.582$, $P<0.025$), stories adjustment ($F(1, 63)=4.771$, $P<0.05$), naturalness of facial expressions ($F(1, 63)=5.268$, $P<0.05$), personality ($F(1, 63)=6.259$, $P<0.025$), engagement ($F(1, 63)=4.603$, $P<0.05$) and overall tour experience ($F(1, 63)=10.160$, $P<0.025$).

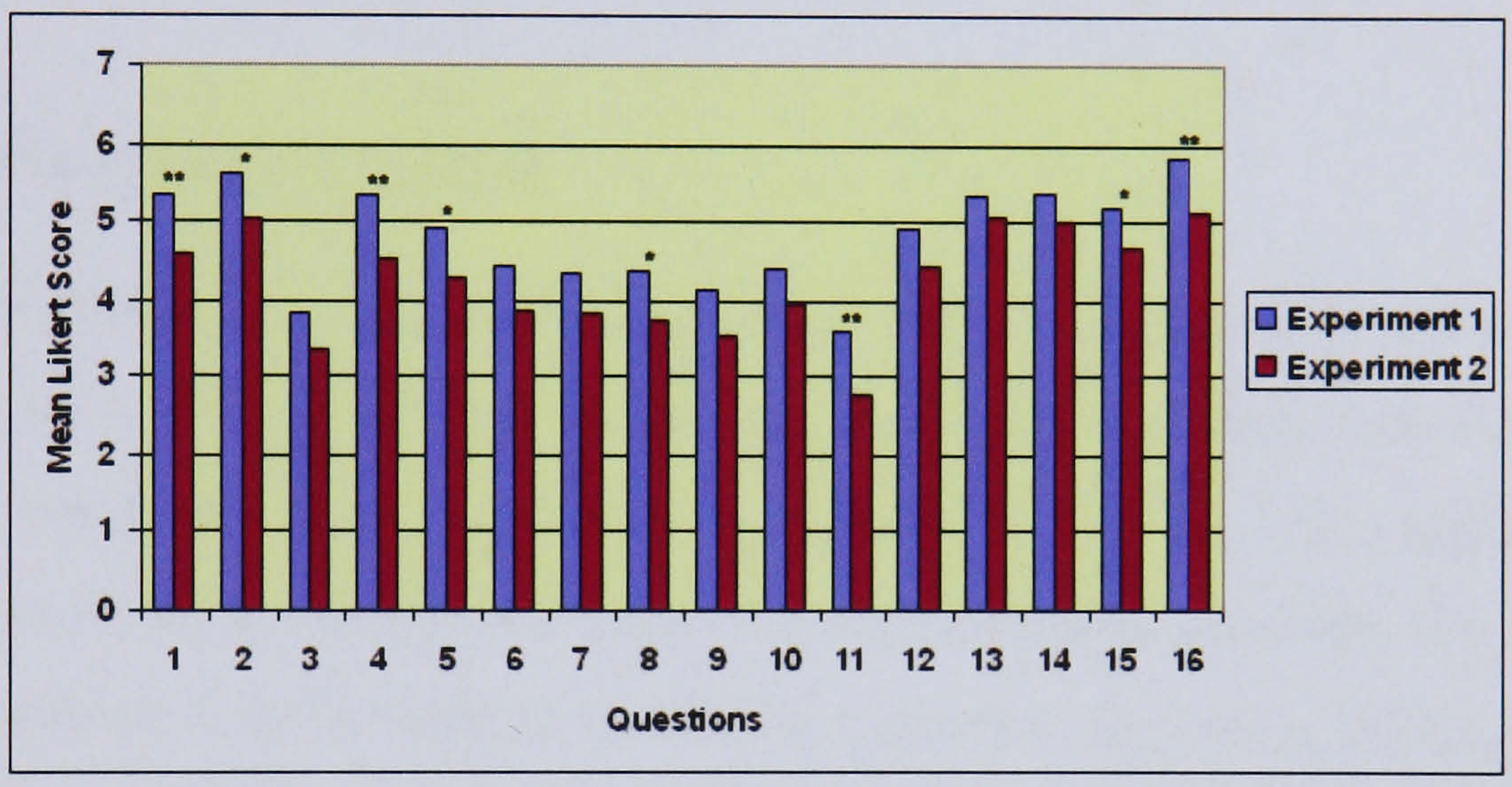


Figure 7.70: Significant differences in omnibus F-test between Experiment 1 and Experiment 2 (* $P<0.05$, ** $P<0.025$)

Discussion

The effects of the Guide across the DVs in the factorial MANOVA test further confirmed the findings of the one-way MANOVA tests discussed in Section 7.3.6 and Section 7.3.7. Additionally, it detected an effect not significant in the previous tests. The participants who interacted with the emotional guide found the stories more emotional (Q3) than those who interacted with the non-emotional guide. This indicates that the inclusion of attitude in the guide is noticeable. As for the test on effects of Experiment, interestingly and obviously from Figure 7.70, all DVs received a higher rating in Experiment 1 than in Experiment 2. This could be simply a coincidence in the sample group. On the other hand, the interaction time might have affected the participants' experience and perception of the guide. The reason that significant effects of the Experiment were not detected may be because the time gap for the experiments was not wide enough. Since the length of tour very much depended on the number of stories listened to at each location, the short tour might end up taking about the same amount of time as the long tour if the participant listened to many stories (more than three stories) at all locations. This would mean that the participants in the short tour would have almost similar experience and amount of interaction with the guide as in the long tour, leading to no noticeable differences.

7.3.9 Motivation Level

As the participants were required to listen to at least three stories at each location, this suggests a considerable variation in the total number of stories they listened to. Hence, the total number of stories is another DV to take into consideration because it could be a possible predictor of the participants' motivation level.

In Experiment 1, the average total number of stories listened to by participants who interacted with Guide A is 32.46, Guide B is 45.42 and Guide C is 39. This variable was analysed using single factor ANOVA. No significant difference was detected between guides. In Experiment 2, the average total number of stories listened to by participants of Guide A is 23.5, Guide B is 33.4 and Guide C is 28. Again, no significant effect was detected between guides in the ANOVA test. These results showed a trend of motivation level starting from Guide B, followed by Guide C and lastly Guide A in decreasing order which contradicted our prediction. Hence, further evaluation is necessary to find out the reason for this pattern.

However, it can be observed that the total number of stories listened to is correlated with the participants' performance in the recall tests for both experiments. Overall, the participants of Guide B who listened to the most total number of stories scored the worst in the recall test, followed by participants of Guide C who listened to a moderate total number of stories. On the other hand, Guide A's participants who have the least average total number of stories recorded, performed best in the recall test among the three groups.

7.3.10 Area of Interests

For each experiment, MANOVA was performed to test the impact of the different story domains on the linear combinations of DVs. It has to be noted that the test was conducted taking into consideration only the participants who had selected a single interest domain, either 'Science' or 'Military' or 'Social'. Participants who had selected more than one area of interests were excluded from the analysis. The total number of participants in each group is presented in Table 7.10.

Experiments	**Science**	**Military**	**Social**	**Total**
Experiment 1	17	9	9	35
Experiment 2	15	7	8	30

Table 7.10: Number of participants in each story domain

Result

The MANOVA for Experiment 1 was insignificant with Wilks' Lambda=0.076, F=1.704, P=0.077 and partial η^2=0.724. Figure 7.71 compares participants' rating for 'Science' (**C**), 'Military' (**M**) and 'Social' (**S**). The omnibus F-test showed significant differences for degree of resemblance to the real guide (F(2, 32)=4.913, P<0.025), engagement (F(2, 32)=4.175, P<0.025) and overall experience (F(2, 32)=7.446, P<0.025). Table 7.11 lists the mean (standard deviation) for the significant DVs. The Bonferonni test showed that participants who selected 'Science' as their interest perceived the guide as more analogous to its real counterpart than participants who selected 'Social' (C-S=1.25, P<0.025). 'Science' participants reported significantly higher engagement (C-M=0.97, P<0.05) and better overall experience (C-M=0.96, P<0.01) than 'Military' participants .

For Experiment 2, the MANOVA was significant with Wilks' Lambda=0.006, F=4.727 and P=0.001. There was a high association between story domains and

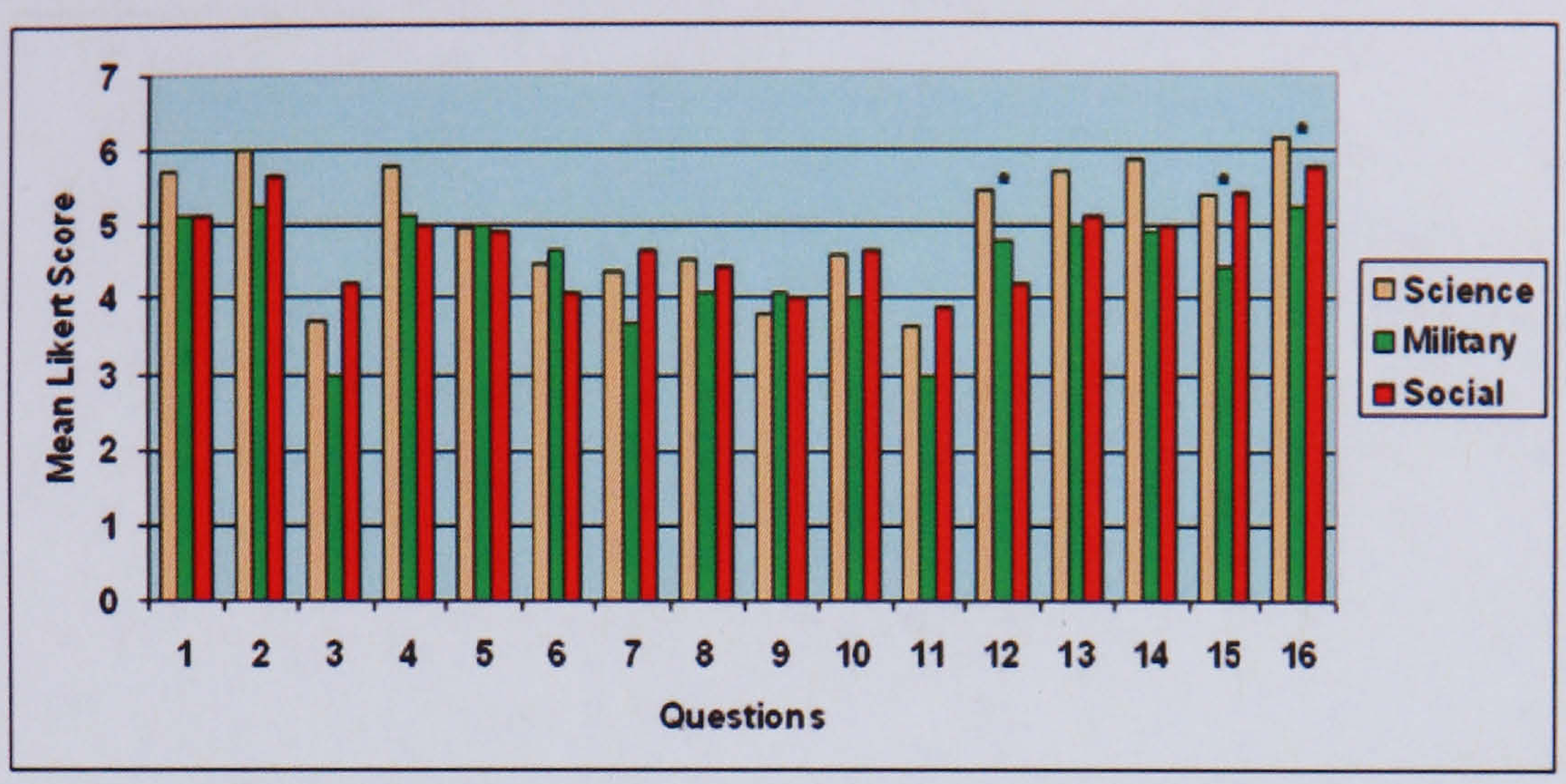


Figure 7.71: Significant differences in rating between 'Science', 'Military' and 'Social' (* P<0.025)

DV	Science (C) (n=17)	Military (M) (n=9)	Social (S) (n=9)
Guide's character:			
Q12:resemblance	5.47 (.624)	4.78 (1.394)	4.22 (1.093)
Participant's experience			
Q15:engagement	5.41 (0.939)	4.44 (.882)	5.44 (.726)
Q16:overall experience	6.18 (.393)	5.22 (.833)	5.78 (.667)

Table 7.11: The significant DVs' means and standard deviations

the combined DVs with partial η^2=0.922. Comparison of participants' rating for the three story domains is provided in Figure 7.72. The omnibus F-test showed significant differences for naturalness of facial expressions (F(2, 27)=5.636, P<0.025) and meaningfulness of tour (F(2, 27)=3.536, P<0.05). The mean (standard deviation) for the significant DVs are listed in Table 7.12. The post-hoc tests showed that the participants in the 'Military' group perceived the guide's facial expressions as more natural (M-S=1.82, P<0.025) and the tour to be more meaningful (M-S=1.58, P<0.05) than the participants in the 'Social' group.

DV	Science (C) (n=15)	Military (M) (n=7)	Social (S) (n=8)
Facial expressiveness:			
Q8:naturalness	3.87 (1.246)	4.57 (.787)	2.75 (.886)
Participant's experience			
Q14:meaningfulness	5.13 (1.060)	5.71 (1.380)	4.13 (1.246)

Table 7.12: The significant DVs' means and standard deviations

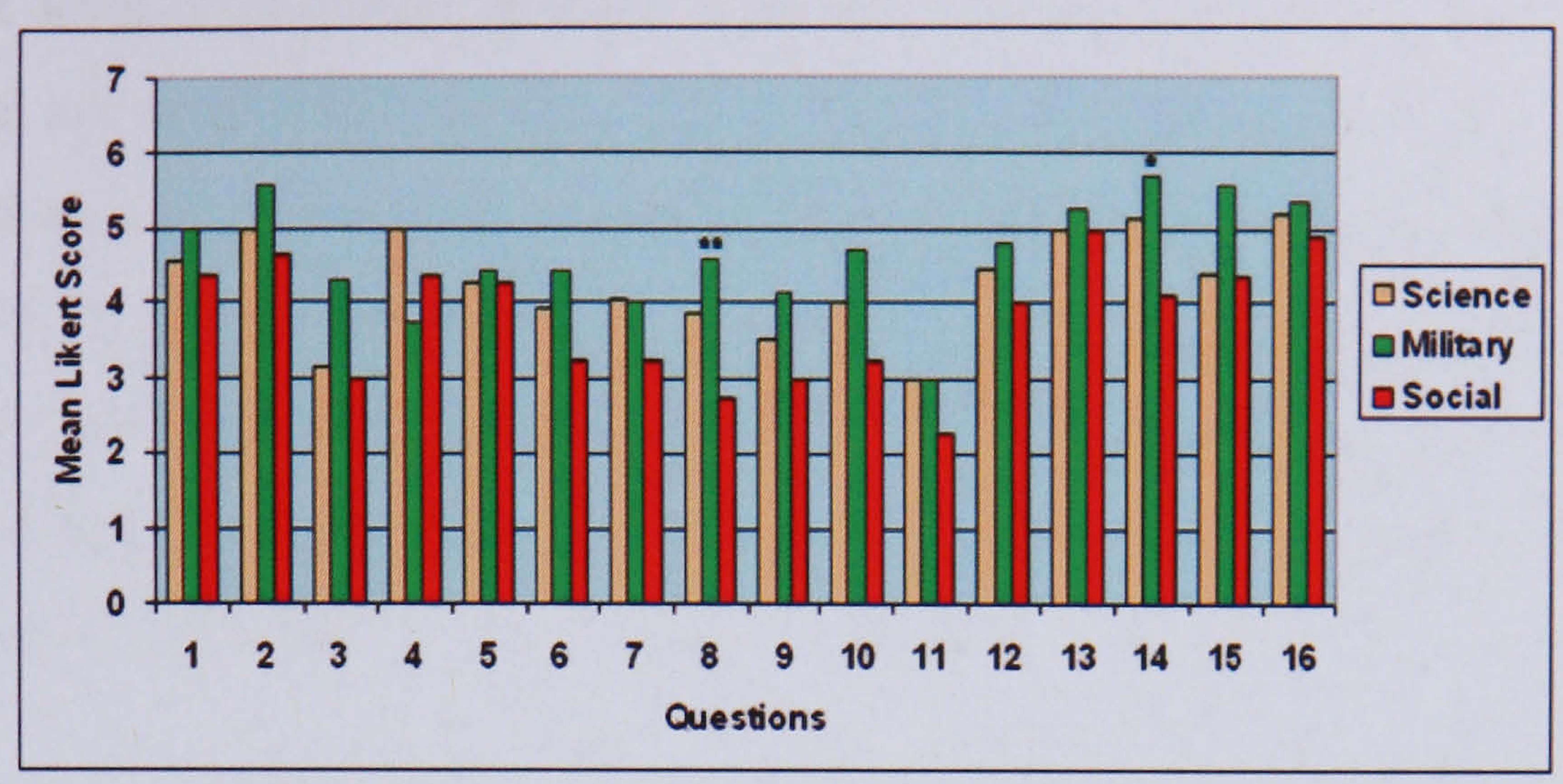


Figure 7.72: Significant differences in rating between 'Science', 'Military' and 'Social' (* P<0.05, ** P<0.025)

Discussion

The analysis on story domains for Experiment 1 showed that the participants perceived the guide who told 'Science' stories as having a higher degree of resemblance to its real counterpart (Q12) than the guide who told 'Social' stories. This might be due to the the tour topic - the atomic bomb, where scientific issues seemed to be more relevant than stories about social life of the Los Alamos inhabitants. The participants who listened to stories on 'Science' subject achieved a higher degree of engagement (Q15) and a better overall experience (Q16) compared to those who listened to stories on 'Military' subject. From these results, we may deduce that 'Science' was the preferred subject among the three story domains. However, it has to be noted that the 'Science' participants also reported a significantly higher rating for degree of compellingness of the navigation system compared to the 'Military' participants (Please refer to Appendix H). Hence, the participants' experiences might have been confounded by the flaw in the interaction technology.

On the other hand, the analysis of Experiment 2 showed that the participants who chose 'Military' as their interest perceived the guide's facial expressions to be more natural than those who chose 'Social' stories. All 'Military' participants were interacting with either Guide A or Guide B. Since the guide was showing the right level of emotions (Guide A) or no emotion (Guide B) and 'Military' personnel are usually quite serious, these could be the reasons why the guide was perceived as natural because it was seemed to be reacting appropriately to the story context. Participants who listened to 'Military' stories also reported the tour as more meaningful than those who listened to 'Social' stories. This again may be explained by the tour topic which relates better to military issues than discussions on social life.

7.4 Summary

This chapter presents some evidence that the Affective Guide can indeed make the stories more interesting, engaging and improve overall tour experience. The study proves that it is not the addition of facial expression alone that makes an interaction more interesting, but the combination of emotions, intelligence and attitude of the guide. Besides that, the story domain seems to have an impact on participants' tour experience. Clearly these effects have been represented in a limited fashion in this study due to the number of participants tested. Furthermore, the between-subjects design and the adjustment of alpha level in the post-hoc test make it relatively difficult to obtain significant differences, but there is no obviously preferable alternative.

It should also be noted that in this study we only examined short-term effects. It is quite possible that other effects could be found if subjects are asked to interact with the guide over a longer term. Other effects may also be observed if the participants take the tour on a nice summer day rather than on a freezing winter day. In order to improve the reliability of the test, a larger group of subjects is required and the technical problems with the current technologies have to be solved. Control might need to be imposed on factors like number of stories listened to at each location and interaction pattern, however, this may also lead to undesirable effects on the participants' experience.

Chapter 8

Conclusions and Future Work

I may not have gone where I intended to go, but I think I have ended up where I intended to be
- *Douglas Adams, British comic writer*

Every end is a new beginning.
- *Proverb*

8.1 Conclusion

We have proposed a biologically-inspired body-mind architecture for behaviour and belief regulation based on emotional states. Our architecture allows the design of a flexible virtual guide that mediates between internal and external stimuli to elicit an adaptive behavioural response that serves self-maintenance functions. Emotion is an integral part of the architecture rather than an optional add-on. This is compatible with the notion that emotion is crucial for behavioural control and decision making processes as suggested in Section 3.1.

The emotions of the guide are triggered by conditions that are evaluated as being of significance to its 'well-being', establishing the desired relation between the guide and its interaction environment. Emotions have not been hand-crafted or pre-generated, but emerge from modulation of cognitive processing, hence, produce a rich set of expressions. In response to the interaction environment conditions, both motivation and modulating parameters elicit appropriate behavioural responses to become active at the right time so as to achieve the active intention. The interaction between motivators and modulators affects the internal states of the guide that in turn influence the choice of active intention and the processing strategy.

The guide presents personalised stories by improvising taking into consideration the user's interests, its own interests and the previously told stories in priority order. The guide expresses its attitude through perspective information stored in its emotional memories. It includes its own past experiences and ideological perspectives in narration, hence telling the user facts as well as its autobiography. Throughout the tour session, the guide performs a continual update of its beliefs about the user's interests and adjusts stories based on the user's feedback to ensure that its presentation is always relevant to the user's expectation. By adapting its behaviour, the guide's emotional responses mirror those of biological systems, consistent with what a human might expect, hence should seem plausible to a human. The resulting values of cognitive modulation has a corresponding affective display. The simple mapping of facial features onto the emotional dimension space has proved to produce natural and believable facial expressions.

Results showed that with the inclusion of attitude, a more distinctive personality is observed and more interesting stories are generated. Expression of emotions per se does not improve interaction experience but a combination of both emotional regulation and attitude does. The studies presented showed that while the perception of the intelligence of the guide does not improve with inclusion of emotions and attitude, an enhanced tour experience is achieved. These results are consistent with the hypothesis that an affective guide with attitude makes interaction more interesting, engaging and improves tour experiences. The studies imply an interesting relationship between interaction time and the strength of improvement in tour experience. A relation between story domains and the participants' tour experiences also seems to exist. Finally, the effect of weather conditions on information retention and tour experience must not be neglected.

8.2 Contributions

This research includes a set of novel contributions and some secondary contributions to knowledge as below.

8.2.1 Novel Contributions

We have described the design of a novel body-mind architecture for emotion, behaviour and belief regulation of a virtual guide, presented in Chapter 6. This involves the integration of a biologically-inspired model of emotions and a storytelling system. An extension to the traditional semantic memory of a virtual guide has been achieved with the inclusion of emotional memory. A structure for coding emotional memory is presented where each emotional memory element is tagged with 'arousal' and 'valence' values. Additionally, a novel facial mapping mechanism onto the emotional dimensions of arousal and valence has been proposed. As opposed to existing approaches that use the facial action units for mapping, we utilise the different facial features: the eyes, the mouth and the eyebrows. This approach is flexible, reusable and capable of generating an infinite range of facial expressions. Finally, a proposal for the theoretical relationship between emotions and ideology is constructed in Chapter 4.

8.2.2 Secondary Contributions

As for the secondary contributions, a reusable source-destination generation algorithm has been designed. A continuous navigation planner (Section 5.3) that provides the user with directional instructions and guides them during the tour session has also been developed. In the implementation of the prototype Affective Guide system presented in Section 5.2.1, the integration of various mobile components including a PDA, a global positioning system and a text-to-speech system has been demonstrated. A survey on tour guides' experiences was carried out and the findings were summarised in Section 5.1 with the survey data attached in Appendix A. Finally, the results obtained from the evaluation with real users on the guide's storytelling capabilities, guide's facial expressiveness, guide's character, participant's tour experience, user interface and participant's recall level are presented and discussed in Chapter 7. Complete results can be found in Appendix H.

8.3 Future Work

There are many improvements that could further this research. It would be interesting to incorporate biometric sensors for detection of the user's physiological states for a more accurate feedback on the user's feeling. This would require a mechanism for mapping the obtained information to the different motivators of significance to the guide's well-being. Additionally, it would reduce touches and clicks, and maintain 'head-up' interaction, hence reducing distractions to the appreciation of the attraction site during the tour. It may also allow the guide to adapt the tour not only to the user's interest needs, but also to their physiological needs such as state of tiredness, attentional focus, etc.

In the current implementation, the arousal and valence values for the emotional memories are given and hand-coded by us. These values are used in the retrieval process to influence the guide's current emotional state and allow re-experience of emotions. In order to achieve a more accurate judgment of these values for each event, to allow appropriate reflection during storytelling, a close collaboration with psychologists would be beneficial. A psychologist's view is an advantage for generation of the non-emotional and emotional memory content to ensure that the stories presented by the non-emotional guide are completely free from any emotional tinge.

In reality, emotions act on memory at all points from encoding to consolidation to retrieval. In the Affective Guide, this process can be seen in the encoding, consolidation and retrieval of the user's interests model but not on the guide's emotional memories. It will be desirable if a mechanism can be devised for encoding emotional memories as experienced by individuals when a particular event takes place. In other words, instead of manually simulating past experiences for the guide, these experiences are recorded as they happen. An authoring tool that can capture and translate these experiences into stories may serve a useful purpose in this case. By doing so, the constraint on the amount of content for narration which is a common problem in storytelling systems will be eliminated. A more realistic version of life stories can also be generated. Moreover, to further improve coherence for narrative construction, natural language approaches such as Rhetorical Structure Theory [Mann and Thompson, 1988] or the approach used in ILEX[1] [O'Donnell et al., 2000, 2001] ought to be considered.

Emotional memory retrieval based on mood congruency is another interesting direction to explore. As mentioned in Section 4.3, we usually retrieve memory files that are directly consistent with our current mood, hence, it could be possible that a guide who tells stories based on its active emotions will be perceived as more realistic and believable. As for the facial animation of the guide, a morphing technique would definitely be a benefit in allowing smoother changes across expressions.

Although there is some evidence that an affective guide with attitude can make interaction more interesting, engaging and improve overall tour experience, more evaluations are necessary to arrive at a more definite result. Obviously, the technical obstacles have to be overcome before this is possible and hopefully technological developments in the near future will allow an improved realisation. Since it has been demonstrated that emotional expressions alone do not make the guide more enjoyable, further evaluation can omit the random emotions guide and focus solely on the differences between the emotional and the non-emotional guide. It would be interesting to prolong the length of the tour to see if the impact of the longer interaction time on the user's experience is as we predicted, that is, a more powerful improvement. Furthermore, it could test how long the interaction with the emotional guide should be before diminishing returns occur.

Next, a measure to find the relationship between narrative domain and gender would be interesting. As mentioned in Chapter 7, a further verification of the weather effect on the user's experience and recall level is necessary. A mechanism

[1]http://www.hcrc.ed.ac.uk/ilex/

to ensure consistency in the number of stories listened to must be devised to ensure that the participants' performance is not confounded by this variable. It would be more realistic if a real attraction is utilised instead of an imagined site, so that the conflicting visual cues do not impact the user's tour experience.

We advanced the view in Section 5.2 that by making users aware of the existence of multiple interpretations of the same event, they become more analytical and have a deeper learning experience. This view has not been evaluated at present. It will be interesting to design a context where the user can listen to different stories from different personality guides on the same subject matter to see how it affects their learning experience. This feature may be tested in a lab using conventional computers and a virtual environment. Since this involves subjective variables, the participation of psychologists in the test design and analysis would be useful.

Further evaluation on the relationship between the participants' motivation level and the guides is necessary since the results of the current test were exposing a pattern contradictory to our prediction. Moreover, the effect of the story domains on participants' experience requires deeper investigation.

Finally, a mechanism that keeps track of the user's interaction history is an add-on so that the guide can pick up where the user left off in its next interaction. This is especially useful as the system is designed for outdoor attractions where the possibility of taking a tour is very much subject to weather condition. Automated capture of the user's experience using microphone and camera will also allow later access to a rich record of that experience. Furthermore, by having this information, follow-up data may be provided in future interactions.

8.4 Concluding remarks

This thesis provides a novel body-mind design to manage the emotions, behaviour and belief in virtual guides. The regulation system provides a unified approach with respect to the assessment of input, the modulation of cognitive processes, the representation of 'emotional' states, adaptation of story generation, adjustment of beliefs and the generation of facial expressions. Taken as a whole, these affective responses encourage the human to treat the guide as an intelligent and socially aware creature, hence making them willing to share their feelings and opinions to allow the guide to personalise and establish a unique tour experience for them. The author hopes that this work takes a step towards the future mobile tour guide system.

Appendix A

Tour Guide Survey Data

A.1 Questions and Results of informal chats

A.1.1 Relevant questions asked during the informal chat

1. What are the requirements to be a tour guide?
2. Do your own experiences affect the story told?
3. How do you plan the route of the tour?
4. Do you think visitors' interests are important factors in planning the story to tell?
5. What do you usually do to attract the visitors' attention?
6. Do you like visitors' interactions during the tour?
7. What do you do to reduce idleness as you take the visitors from one place to another?
8. Do the visitors (eg. Origin, age, role, etc.) affect the story told?
9. How do you make sure that the visitors are on the same track as you during the tour?

A.1.2 What were found from informal chats, participation and observation?

1. The guide has essential knowledge about the tourist attraction.
2. The guide picks up interesting story/points of interest to tell.
3. The guide includes his/her own experience while telling the stories.
4. The guide show things based on his/her own interest.
5. The guide takes into consideration the visitors' interests.
6. The guide feels delighted to received interaction from the visitors.
7. The guide maintains eye contact with the visitors from time to time.
8. The origin of the visitors may affect the story told, whether general or detail information is to be provided.
9. The role, personality, age, etc of the guide can also affect the story told.
10. Sometimes, the guide provides a detour based on visitors' interest or as requested.
11. The guide will ask simple questions during the tour to keep users' attention. Example: Do you know what is this?, Do you know what is it for?, Isn't that nice?, etc
12. Visitors can also ask questions during the tour.
13. To reduce idleness during the walk from one point of interest to the other, the guide will chat with the users. Visitors will usually chat among themselves too.
14. The guide makes comments about facts or events from time to time, giving his/her own viewpoint.
15. The guide will also links related story elements when relevant.

16. The guide presents emotional and physical expressions through facial and body movements during the story-telling process.

17. The most important thing as stressed by one of the guide is to keep the information pretty basic. Detail information will only be provided as necessarily when requested by the visitors.

18. Themed tours are provided for interested visitors.

A.2 Guide's Attributes

Name of Tour	:	Audio Tour at Stonehenge
Type of Guide	:	Audio
Tour duration	:	-
Outdoor/Indoor	:	Outdoor
Participants	:	1

Requirements on guide	**Yes/No**	**Comment**
Communication skill	-	Not applicable
Knowledge on subjects	-	Not applicable
Expressivity	-	Not applicable
Acting skills	-	Not applicable
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Recorded speech, stone cracking sound, background effect
Visual	Yes	Historical Stones
Body language	No	
Facial expression	No	
Music	No	
Multiple characters	No	
Additional tools	No	
Story content	**Yes/No**	**Comment**
Facts	Yes	Historical, archeological
Perspective information	No	
Guide's experience	No	
Guide's interest	No	
Visitor's interest	No	
Beliefs	Yes	Ancient beliefs
Imaginary	No	
Same story every time	No	
Linked story elements	Yes	Chronologically, historically
Means for interaction	**Yes/No**	**Comment**
Verbal	No	
Facial expression	No	
Body language	No	
GUI	Yes	Buttons interface
Interaction style	**Yes/No**	**Comment**
Question and answer	No	
Conversational	No	
Eye contact	No	
Physical/body language	No	
Direct participation	No	
Button pressing	Yes	

Table A.13: Guide's criteria for Stonehenge Audio Tour

Name of Tour : Audio Tour at Witley Court, Shropshire
Type of Guide : Audio
Tour duration : -
Outdoor/Indoor : Outdoor
Participants : 1

Requirements on guide	**Yes/No**	**Comment**
Communication skill	-	Not applicable
Knowledge on subjects	-	Not applicable
Expressivity	-	Not applicable
Acting skills	-	Not applicable
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Recorded speech
Visual	Yes	Buildings and garden
Body language	No	
Facial expression	No	
Music	Yes	While description of the ballroom is presented
Multiple characters	Yes	Housekeepers, owner
Additional tools	No	
Story content	**Yes/No**	**Comment**
Facts	Yes	Historical, lifestyle
Perspective information	Yes	Housekeeper's versus owner's viewpoints
Guide's experience	No	
Guide's interest	No	
Visitor's interest	No	
Beliefs	Yes	
Imaginary	No	
Same story every time	No	
Linked story elements	Yes	Chronologically
Means for interaction	**Yes/No**	**Comment**
Verbal	No	
Facial expression	No	
Body language	No	
GUI	Yes	Buttons interface
Interaction style	**Yes/No**	**Comment**
Question and answer	No	
Conversational	No	
Eye contact	No	
Physical/body language	No	
Direct participation	No	
Button pressing	Yes	

Table A.14: Guide's criteria for Witley Court Audio Tour

Name of Tour	:	Introductory Tour of the Royal Museum of Scotland
Type of Guide	:	Volunteer
Tour duration	:	30 minutes
Outdoor/Indoor	:	Indoor
Participants	:	2 to 5

Requirements on guide	**Yes/No**	**Comment**
Communication skill	Yes	Basic skill is sufficient
Knowledge on subjects	Yes	
Expressivity	No	
Acting skills	No	
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Human speech
Visual	Yes	Objects presentation
Body language	Yes	
Facial expression	Yes	
Music	No	
Multiple characters	No	
Additional tools	No	
Story content	**Yes/No**	**Comment**
Facts	Yes	Art, Science
Perspective information	Yes	
Guide's experience	Yes	
Guide's interest	Yes	
Visitor's interest	Yes	
Beliefs	Yes	
Imaginary	No	
Same story every time	No	Depends on visitor's interest
Linked story elements	Yes	
Means for interaction	**Yes/No**	**Comment**
Verbal	Yes	
Facial expression	Yes	
Body language	Yes	
GUI	No	
Interaction style	**Yes/No**	**Comment**
Question and answer	Yes	Bidirectional, the guide asked simple questions to invoke interaction
Conversational	Yes	
Eye contact	Yes	
Physical/body language	Yes	
Direct participation	No	
Button pressing	No	

Table A.15: Guide's criteria for the Royal Museum of Scotland Tour

Name of Tour	:	Treasure of the Museum of Scotland
Type of Guide	:	Volunteer - A historian
Tour duration	:	1 hour
Outdoor/Indoor	:	Indoor
Participants	:	10 to 15

Requirements on guide	**Yes/No**	**Comment**
Communication skill	Yes	Basic skill is sufficient
Knowledge on subjects	Yes	
Expressivity	No	
Acting skills	No	
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Human speech
Visual	Yes	Artifacts on display
Body language	Yes	
Facial expression	Yes	
Music	No	
Multiple characters	No	
Additional tools	No	
Story content	**Yes/No**	**Comment**
Facts	Yes	Historical, basic information only unless user request for more information
Perspective information	Yes	
Guide's experience	Yes	
Guide's interest	Yes	
Visitor's interest	Yes	
Beliefs	Yes	
Imaginary	No	
Same story every time	No	Depends on visitor's interest
Linked story elements	Yes	Chronological or according to theme
Means for interaction	**Yes/No**	**Comment**
Verbal	Yes	
Facial expression	Yes	
Body language	Yes	
GUI	No	
Interaction style	**Yes/No**	**Comment**
Question and answer	Yes	Bidirectional, the guide asked simple questions to invoke interaction and get hints on visitors' interests
Conversational	Yes	
Eye contact	Yes	
Physical/body language	Yes	
Direct participation	No	
Button pressing	No	

Table A.16: Guide's criteria for Treasure of the Museum of Scotland Tour

Name of Tour : Highland Folk Museum
Type of Guide : Scottish National Trust Tour Guide
Tour duration : 1 hour
Outdoor/Indoor : Indoor and outdoor
Participants : 4

Requirements on guide	**Yes/No**	**Comment**
Communication skill	Yes	Basic skill is sufficient
Knowledge on subjects	Yes	
Expressivity	No	
Acting skills	No	
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Human speech
Visual	Yes	Artifacts
Body language	Yes	
Facial expression	Yes	
Music	No	
Multiple characters	No	
Additional tools	No	
Story content	**Yes/No**	**Comment**
Facts	Yes	Historical, basic information
Perspective information	Yes	
Guide's experience	Yes	Not much
Guide's interest	Yes	
Visitor's interest	Yes	
Beliefs	Yes	
Imaginary	Yes	Imagination on how life was like for the highland folk in the old times
Same story every time	No	Depends on visitor's interest
Linked story elements	Yes	Chronological, evolution of tools used for daily activities among the highland folks
Means for interaction	**Yes/No**	**Comment**
Verbal	Yes	
Facial expression	Yes	
Body language	Yes	
GUI	No	
Interaction style	**Yes/No**	**Comment**
Question and answer	Yes	Bidirectional
Conversational	Yes	Quite a lot of conversation took place as the outdoor tour involves walking from one place to another
Eye contact	Yes	
Physical/body language	Yes	
Direct participation	No	
Button pressing	No	

Table A.17: Guide's criteria for Highland Folk Museum Tour

Name of Tour	:	Penang Island, Malaysia
Type of Guide	:	Local guide cum driver
Tour duration	:	Half-day
Outdoor/Indoor	:	Indoor and Outdoor
Participants	:	2

Requirements on guide	**Yes/No**	**Comment**
Communication skill	Yes	Basic skill is sufficient
Knowledge on subjects	Yes	
Expressivity	No	
Acting skills	No	
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Human speech
Visual	Yes	Artifacts and buildings
Body language	Yes	
Facial expression	Yes	
Music	No	
Multiple characters	No	
Additional tools	No	
Story content	**Yes/No**	**Comment**
Facts	Yes	Historical, lifestyle of the local community
Perspective information	Yes	
Guide's experience	Yes	
Guide's interest	Yes	
Visitor's interest	Yes	
Beliefs	Yes	Both the guide's and the local communities'
Imaginary	No	
Same story every time	No	
Linked story elements	Yes	Connection between buildings and people
Means for interaction	**Yes/No**	**Comment**
Verbal	Yes	
Facial expression	Yes	
Body language	Yes	
GUI	No	
Interaction style	**Yes/No**	**Comment**
Question and answer	Yes	Bidirectional
Conversational	Yes	Quite a lot of conversation took place
Eye contact	Yes	
Physical/body language	Yes	
Direct participation	Yes	Participated in local activities
Button pressing	No	

Table A.18: Guide's criteria for Penang Island Tour

Name of Tour	:	Europe Tour
Type of Guide	:	Professional Guide
Tour duration	:	A week
Outdoor/Indoor	:	Indoor and Outdoor
Participants	:	40

Requirements on guide	**Yes/No**	**Comment**
Communication skill	Yes	Besides communication skill, enthusiasm and motivation are vital to ensure enjoyable experiences for trip members. Friendliness and mutual understanding between the guide and the members are also important
Knowledge on subjects	Yes	Vast knowledge about different topics
Expressivity	Yes	
Acting skills	Yes	For performances and activities
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Human speech
Visual	Yes	Artifacts, buildings, scenic views
Body language	Yes	
Facial expression	Yes	
Music	Yes	As entertainment
Multiple characters	No	
Additional tools	Yes	Tools for performances and activities, presents for exchange during Christmas
Story content	**Yes/No**	**Comment**
Facts	Yes	Historical, lifestyle, arts, science, etc.
Perspective information	Yes	
Guide's experience	Yes	
Guide's interest	Yes	
Visitor's interest	Yes	
Beliefs	Yes	Community beliefs, ancient beliefs
Imaginary	No	
Same story every time	No	
Linked story elements	Yes	Historical link of locations; relationship link of people
Means for interaction	**Yes/No**	**Comment**
Verbal	Yes	
Facial expression	Yes	
Body language	Yes	
GUI	No	
Interaction style	**Yes/No**	**Comment**
Question and answer	Yes	Bidirectional
Conversational	Yes	Between the guide and trip members, also among members
Eye contact	Yes	
Physical/body language	Yes	
Direct participation	Yes	In activities and performances, first hand experience on site of attraction
Button pressing	No	

Table A.19: Guide's criteria for Europe Tour

Name of Tour	:	Hualien, an aboriginal settlement in Taiwan
Type of Guide	:	Professional Guide
Tour duration	:	2 days
Outdoor/Indoor	:	Indoor and Outdoor
Participants	:	20

Requirements on guide	**Yes/No**	**Comment**
Communication skill	Yes	The guide must be full of enthusiasm and active to ensure an enjoyable trip
Knowledge on subjects	Yes	Vast knowledge about aboriginal group and the settlement is essential
Expressivity	Yes	
Acting skills	No	
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Human speech
Visual	Yes	Aboriginal community, settlement, artifacts, performances, scenic views
Body language	Yes	
Facial expression	Yes	
Music	Yes	As entertainment
Multiple characters	No	
Additional tools	No	
Story content	**Yes/No**	**Comment**
Facts	Yes	Historical, norms, lifestyle
Perspective information	Yes	
Guide's experience	Yes	
Guide's interest	Yes	
Visitor's interest	Yes	
Beliefs	Yes	Aboriginal beliefs, legend
Imaginary	No	
Same story every time	No	
Linked story elements	Yes	Connection between locations, artifacts
Means for interaction	**Yes/No**	**Comment**
Verbal	Yes	
Facial expression	Yes	
Body language	Yes	
GUI	No	
Interaction style	**Yes/No**	**Comment**
Question and answer	Yes	Bidirectional
Conversational	Yes	A lot of conversation took place
Eye contact	Yes	
Physical/body language	Yes	
Direct participation	Yes	Interacting with real aboriginal, tasting their traditional food and participating in cultural activities
Button pressing	No	

Table A.20: Guide's criteria for An Aboriginal Settlement in Taiwan Tour

Name of Tour	:	Dalwhinnie Distillery
Type of Guide	:	Professional Whisky Guide
Tour duration	:	45 minutes
Outdoor/Indoor	:	Indoor
Participants	:	15 to 20

Requirements on guide	**Yes/No**	**Comment**
Communication skill	Yes	Basic skill is sufficient
Knowledge on subjects	Yes	Expertise on whisky production
Expressivity	No	
Acting skills	No	
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Human speech
Visual	Yes	Raw material, machines, final product
Body language	Yes	
Facial expression	Yes	
Music	No	
Multiple characters	No	
Additional tools	No	
Story content	**Yes/No**	**Comment**
Facts	Yes	The whisky production process
Perspective information	No	
Guide's experience	Yes	
Guide's interest	Yes	
Visitor's interest	Yes	
Beliefs	No	
Imaginary	No	
Same story every time	No	
Linked story elements	Yes	Sequential steps of production process
Means for interaction	**Yes/No**	**Comment**
Verbal	Yes	
Facial expression	Yes	
Body language	Yes	
GUI	No	
Interaction style	**Yes/No**	**Comment**
Question and answer	Yes	Bidirectional, tourists asked questions
Conversational	Not much	
Eye contact	Yes	
Physical/body language	Yes	
Direct participation	Yes	Tasting of whisky
Button pressing	No	

Table A.21: Guide's criteria for Dalwhinnie Distillery Tour

Name of Tour	:	Underground Tour at South Bridge, Edinburgh
Type of Guide	:	Witch-like guide
Tour duration	:	50 minutes
Outdoor/Indoor	:	Indoor and in the dark
Participants	:	10

Requirements on guide	**Yes/No**	**Comment**
Communication skill	Yes	Basic skill
Knowledge on subjects	Yes	
Expressivity	Yes	Through voice
Acting skills	No	
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Human speech, emotive
Visual	Not much	The underground was dark
Body language	Not clear	
Facial expression	Not clear	
Music	No	
Multiple characters	No	
Additional tools	Yes	Torchlight for lighting and highlighting story elements
Story content	**Yes/No**	**Comment**
Facts	Yes	Historical
Perspective information	No	
Guide's experience	Yes	Experiences with other groups of visitors
Guide's interest	Yes	
Visitor's interest	No	
Beliefs	Yes	Beliefs about the past occupants
Imaginary	Yes	
Same story every time	No	The content can be similar
Linked story elements	Yes	Chronologically, previously told stories
Means for interaction	**Yes/No**	**Comment**
Verbal	Yes	
Facial expression	Not clear	
Body language	Not clear	
GUI	No	
Interaction style	**Yes/No**	**Comment**
Question and answer	Not much	
Conversational	Not much	
Eye contact	Not clear	
Physical/body language	Not clear	
Direct participation	No	
Button pressing	No	

Table A.22: Guide's criteria for Underground Tour

Name of Tour	:	York City Haunted Tour
Type of Guide	:	Ghostly-dressed guide
Tour duration	:	1 hour
Outdoor/Indoor	:	Outdoor and at night
Participants	:	15-20

Requirements on guide	**Yes/No**	**Comment**
Communication skill	Yes	
Knowledge on subjects	Yes	
Expressivity	Yes	Through voice and facial expression
Acting skills	Yes	Some acting skill is essential to create suspension of disbelief in the user
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Emotive human speech, scary scream
Visual	Yes	Haunted houses, churches, backyard, etc.
Body language	Yes	
Facial expression	Yes	Very expressive
Music	No	
Multiple characters	Yes	Hidden helpers to create some shocking effect or background sound
Additional tools	Yes	Fake knife, blood spill, etc.
Story content	**Yes/No**	**Comment**
Facts	No	
Perspective information	No	
Guide's experience	No	
Guide's interest	Yes	
Visitor's interest	No	
Beliefs	Yes	
Imaginary	Yes	
Same story every time	No	The content can be similar
Linked story elements	Yes	Previously told stories
Means for interaction	**Yes/No**	**Comment**
Verbal	Yes	
Facial expression	Yes	
Body language	Yes	
GUI	No	
Interaction style	**Yes/No**	**Comment**
Question and answer	Not much	
Conversational	Not much	
Eye contact	Yes	
Physical/body language	Yes	
Direct participation	Yes	Visitor as the victim in the story
Button pressing	No	

Table A.23: Guide's criteria for York City Haunted Tour

Name of Tour	:	Guided Tour (Traverse 5)
Type of Guide	:	Peter Reder
Tour duration	:	1 hour and 10 minutes
Outdoor/Indoor	:	Indoor around the mysterious underground passages in one of the Ediburgh's architectural gems, McEwan
Participants	:	About 15

Requirements on guide	**Yes/No**	**Comment**
Communication skill	Yes	
Knowledge on subjects	Yes	
Expressivity	Yes	Through voice and facial expression
Acting skills	Yes	Some acting skill is essential to make the visitor believe the imaginative part
Means for presentation	**Yes/No**	**Comment**
Audio	Yes	Human speech
Visual	Yes	Photos, artifacts, video, projection slides
Body language	Yes	
Facial expression	Yes	Very expressive
Music	No	
Multiple characters	Yes	Usher to hold the torchlight and show the pictures
Additional tools	No	
Story content	**Yes/No**	**Comment**
Facts	Yes	
Perspective information	Yes	
Guide's experience	Yes	
Guide's interest	Yes	
Visitor's interest	Yes	
Beliefs	Yes	
Imaginary	Yes	To evoke memories
Same story every time	No	The content can be similar
Linked story elements	Yes	Previously told stories
Means for interaction	**Yes/No**	**Comment**
Verbal	Yes	
Facial expression	Yes	
Body language	Yes	
GUI	No	
Interaction style	**Yes/No**	**Comment**
Question and answer	Not much	
Conversational	Not much	
Eye contact	Yes	
Physical/body language	Yes	
Direct participation	No	
Button pressing	No	

Table A.24: Guide's criteria for Traverse 5 Guided Tour

Appendix B

Sample Story Elements

```
name G01
type Responsibility
subjects O-Division
objects Little-Boy
effects G02 1
divisions O-Division
concepts Little-Boy
attributes atomic-bomb 1 reorganisation 1
location OOD 1
text After the reorganisation, <s> the Ordnance Engineering Division
</s> was given sole responsibility for developing the Little Boy and
arranging its eventual use.
end

name P01
type Complementarity
subjects Niels-Bohr
objects atomic-bomb Franklin-Roosevelt Winston-Churchill
effects P02 1 P04 0.8
personnel Niels-Bohr Winston-Churchill
attributes atomic-bomb 1 atomic-control 1
location OOD 1
text During the 1940s, <s> Bohr </s> in London and Los Alamos was not
to help in making the bomb, he was working out the revolutionary
consequences of the bomb and he meant to communicate his revelation
to the heads of state who could act on it: Franklin Roosevelt and
Winston Churchill.
end

name P04
type Roosevelt-Churchill-discussion
subjects Franklin-Roosevelt Winston-Churchill
objects international-control Japanese atomic-bomb
```

event Roosevelt-Churchill-discussion
personnel Winston-Churchill
attributes atomic-control 1
location OOD 1
text <s> Roosevelt and Churchill </s> rejected international control
and use of the atomic bomb but when the bomb is finally available, it
might perhaps, after mature consideration, be used against the
Japanese, who should be warned that bombardment will be repeated
until they surrender.
end

name P06
type Roosevelt-Churchill-discussion
subjects Franklin-Roosevelt Winston-Churchill
objects Niels-Bohr Russians
event Roosevelt-Churchill-discussion
personnel Winston-Churchill
attributes atomic-control 1
location OOD 1
text <s> Roosevelt and Churchill </s> agreed that enquiries should be
made regarding the activities of Professor Bohr and steps taken to
ensure that he is responsible for no leakage of information
particularly to the Russians.
end

name M03
type Aircraft
subjects B-29
objects aircraft atomic-bomb
attributes carrier 1
location OOD 1
text <s> The B 29 </s> was the only United States aircraft in which
the atomic bomb could be conveniently carried internally, and even
this plane would require considerable modification.
end

name M08
type Target-factors
subjects targets
objects Japanese war
attributes combat-bomb 1 Japanese-bombing 1
location OOD 1
text <s> The Japanese bombing targets </s> were chosen to be places
the bombing would most adversely affect the will of the Japanese
people to continue the war and military in nature.
end

name M011
type Hiroshima

```
subjects Little-Boy
objects Hiroshima
event Hiroshima-bombing
concepts Little-Boy TNT
attributes Japanese-bombing 1
location OOD 1
text <s> Little Boy </s> exploded at 8:16:02, August 6, 1945,
Hiroshima time, one thousand nine hundreds feet above the courtyard
of Shima Hospital, with a yield equivalent to twelve thousands five
hundred tons of TNT.
end

name C03
type Gun-method
subjects gun-method
objects uranium-bomb U235
effects C04 1
concepts gun-method U235
attributes a-bomb 1
location OOD 1
text By the end of 1944, <s> the gun method of detonation </s> seemed
as nearly certain as any untried new procedure can be, the
availability of a uranium gun bomb, then depended only on the
separation of sufficient Uranium 235.
end

name C04
type Uranium
subjects Oak-Ridge
objects U235
concepts U235 Oak-Ridge
attributes nuclear 1
location OOD 1
text By April, 1945, <s> Oak Ridge </s> had produced enough Uranium
235 to allow a near critical assembly of pure metal without hydride
dilution.
end
```

Appendix C

Sample Emotional Story Elements

C.1 A Military's Perspective

```
name EA02
type Target-factors 1
objects targets American
arousal 0.9
valence 0.45
attributes combat-bomb 1
location OOD 1
text It seemed brutal to be talking about burning homes. But we were
engaged in a life and death struggle for national survival, and we
were therefore justified in taking any action that will save the
lives of American soldiers and sailors. We must strike hard with
everything we have at the spot where it will do the most damage to
the enemy.
end

name EA03
type Target-factors 1
objects civilians Japanese American
arousal 0.75
valence 0.45
attributes combat-bomb 1
location OOD 1
text No matter how you slice it, you're going to kill an awful lot of
civilians. Thousands and thousands. But if we do not destroy the
Japanese industry, we were going to have to invade Japan. And how
many Americans will be killed in an invasion of Japan? Five hundred
```

```
thousand seems to be the lowest estimate. Some say a million. We were
at war with Japan. We were attacked by Japan. Do you want to kill
Japanese or would you rather have Americans killed?
end

name EA08
type Codename 1
objects AF-representatives
arousal 0.8
valence 0.75
attributes security 1
location OOD 1
text The Air Force officers tried to make their phone conversations
sound as though they were modifying a plane to carry Roosevelt (the
Thin Man) and Churchill (the Fat Man). Very clever!
end

name EA011
type Aircraft 1
objects Lancaster atomic-bomb
arousal 0.65
valence 0.5
attributes carrier 1
location OOD 1
text Except for the British Lancaster, all other aircraft without
modification would require the atomic bomb to be carried externally.
Of course, we were not about to allow a historic new weapon of war to
be introduced to the world in a British aircraft.
end

name EA016
type Roosevelt-Churchill-discussion 1
objects Franklin-Roosevelt Harry-Truman atomic-bomb
arousal 0.7
valence 0.6
attributes atomic-control 1
location OOD 1
text Certainly, there was no question in my mind or as far as I was
ever aware in the mind of either President Roosevelt or President
Truman or any other responsible person, but that we were developing a
weapon to be employed against the enemies of the United States. After
all this new bomb is just going to be bigger than our present bombs.
end

name EA018
type Roosevelt-Churchill-discussion 1
objects atomic-bomb
arousal 0.65
valence 0.45
```

```
attributes atomic-bomb 1
location OOD 1
text If we did not develop the atomic bomb and demonstrate to the
world its appalling nature, sooner or later some other unscrupulous
power will attempt, unobtrusively and in all secrecy to manufacture
it.
end

name EA019
type Roosevelt-Churchill-discussion 1
objects Niels-Bohr
arousal 0.3
valence 0.35
personnel Niels-Bohr
attributes atomic-control 1
location OOD 1
text I was very much worried about Professor Bohr. How did he come
into this business? He is a great advocate of publicity. It seems to
me that Bohr ought to be confined or at any rate made to see that he
is very near the edge of mortal crimes.
end
```

C.2 A Scientist's Perspective

```
name EC01
type Complementarity 1
objects atomic-bomb
arousal 0.75
valence 0.5
attributes atomic-bomb 1
location OOD 1
text The bomb is a source of terror but for that very reason also a
source of hope, a means of welding together nations by their common
dread of a menacing nuclear standoff. It appeared to me that the very
necessity of a concerted effort to forestall such ominous threats to
civilization would offer quite unique opportunities to bridge
international divergences.
end

name EC02
type Russia 1
objects Winston-Churchill atomic-bomb Soviet-Union
arousal 0.3
valence 0.35
personnel Winston-Churchill
attributes atomic-control 1
location OOD 1
```

```
text Churchill was only too conscious that British power and his
own, was then just a vestige. So long as the Americans and British
had the bomb in sole possession, he could feel that the power had not
altogether slipped away. Churchill deluded himself into not believing
that the 'bomb secret' was not keepable and that the Soviets would
soon have the bomb themselves. It is a sad story.
end

name EC05
type Roosevelt-Churchill-discussion 1
objects Winston-Churchill
arousal 0.45
valence 0.4
attributes atomic-control 1
location OOD 1
text It was, of course, a rather novel situation that a scientist
should try to intervene in world politics, but it was hope that
Churchill, who possessed such imagination and who had often shown
such great vision, would be inspired by the new prospects.
end

name EC07
type Roosevelt-Churchill-discussion 1
objects war Franklin-Roosevelt Winston-Churchill open-world
arousal 0.5
valence 0.5
attributes atomic-control 1
location OOD 1
text With the coming of nuclear weapons the world would arrive at an
entirely new situation that could not be resolved by war. The
situation might be resolved by statesmen sitting down together and
negotiating for mutual security. If they did so, the inevitable
outcome of such negotiations, given the understandable suspicion on
every side, must be an open world.
end

name EC010
type Gun-method 1
objects William-Parsons gun-method
arousal 0.55
valence 0.5
personnel William-Parsons
attributes a-bomb 1
location OOD 1
text I became associated with the gun program when Captain Parsons
was put into the project to take over that work. Our first task was
to set up a test stand few miles north from here where experiments
could be done. We have a gun emplacement, a gun and a sand butt,
which is nothing but a huge box full of sand that we fire projectiles
```

```
into so that we can find the pieces afterwards.
end

name EC017
type Aircraft 1
objects B-29
arousal 0.75
valence 0.6
attributes carrier 1
location OOD 1
text The B 29 was conceived in the late 1930s, by some ambitious
officers within what was then still the Army Air Corps as the vehicle
of their vision of wars fought at great distance by strategic air power.
end

name EC020
type Gun-design 1
objects plutonium-gun
arousal 0.8
valence 0.4
attributes combat-bomb 1
location OOD 1
text We initially thought we could just use a military gun that would
blow a couple of pieces together fast enough to make an explosion.
But fast enough turned out to be really very fast. On top of that,
the whole business had to be carried by a B 29 aircraft and dropped
as a ballistic missile and the Navy or the Army just do not make guns
for those purposes.
end

name EC024
type Hiroshima 1
objects Hiroshima
arousal 0.3
valence 0.1
attributes Japanese-bombing 1
location OOD 1
text At first I refused to believe that the Hiroshima bombing could
be true, but in the end had to face the fact that it was officially
confirmed by the President of the United States. I was shocked and
depressed beyond measure. The thought of the unspeakable misery of
countless innocent women and children was something that I could
scarcely bear.
end
```

Appendix D

Extension Rules

D.1 SE Extension Rules

Subject-Object Extension Rules

Phase 1 Evaluates subject and objects coincidences

Rule 1 If $subject(SE) \cap subject(SSE) \neq 0$

$evaluation = 1 \text{ x } soCriterionWeight$

Rule 2 If $object(SE) \cap subject(SSE) \neq 0$

$evaluation = 0.8 \text{ x } soCriterionWeight$

Rule 3 If $subject(SE) \cap object(SSE) \neq 0$

$evaluation = 0.8 \text{ x } soCriterionWeight$

Rule 4 If $object(SE) \cap object(SSE) \neq 0$

$evaluation = 1 \text{ x } soCriterionWeight$

Phase 2 Evaluates coincidence in type of story elements

Rule 5 If $type(SE) = type(SSE)$

$evaluation = 1.1 \text{ x } evaluation$

Rule 6 If $type(SE) \neq type(SSE)$

$evaluation = 0.9 \text{ x } evaluation$

Phase 3 Evaluates coincidence in concepts of story elements

Rule 7 If $concepts(SE) \cap concepts(SSE) \neq 0$

$evaluation = 1.1$ x $evaluation$

Rule 8 If $concepts(SE) \cap concepts(SSE) = 0$

$evaluation = 0.9$ x $evaluation$

Phase 4 Evaluates coincidence in attributes of story elements

Rule 9 If $attributes(SE) \cap attributes(SSE) \neq 0$

$evaluation = 1.1$ x $evaluation$

Rule 10 If $attributes(SE) \cap attributes(SSE) = 0$

$evaluation = 0.9$ x $evaluation$

Phase 5 Evaluates coincidence in attributes with the guide's interests

Rule 11 If $attributes(SE) \cap attributes(GuideInterests) \neq 0$

$evaluation = 1.0$ x $evaluation$

Rule 12 If $attributes(SE) \cap attributes(GuideInterests) = 0$

$evaluation = 0.9$ x $evaluation$

Phase 6 Evaluates coincidence in attributes with the user's interests

Rule 13 If $attributes(SE) \cap attributes(UserInterests) \neq 0$

$evaluation = 1.0$ x $evaluation$

Rule 14 If $attributes(SE) \cap attributes(UserInterests) = 0$

$evaluation = 0.9$ x $evaluation$

Phase 7 Evaluates suitability of location

Rule 15 If $location(SE) = location(SSE)$

$evaluation = 1.0$ x $evaluation$ x $weightLocSE$

Rule 16 If $location(SE) =$ "*ANY*"

$evaluation = 0.9$ x $evaluation$

Cause-Effect Extension Rules

Rule 17 If SE is the effect of SSE

$$evaluation = 1.0 \text{ x } ceCriterionWeight \text{ x}$$
$$effectWeight(effect(SE), SSE)$$

Rule 18 If SSE is the effect of SE

$$evaluation = 1.0 \text{ x } ceCriterionWeight \text{ x}$$
$$effectWeight(effect(SSE), SE)$$

Rule 19 If SE and SSE is the effect of SE'

$$evaluation = 0.5 \text{ x } ceCriterionWeight \text{ x}$$
$$effectWeight(effect(SE), SE') \text{ x}$$
$$effectWeight(effect(SSE), SE')$$

Rule 20 If SE and SSE is the cause of SE'

$$evaluation = 0.5 \text{ x } ceCriterionWeight \text{ x}$$
$$effectWeight(effect(SE'), SE) \text{ x}$$
$$effectWeight(effect(SE'), SSE)$$

D.2 EE Extension Rules

Phase 1 Evaluates location suitability

Rule 1 If $location(EE) = currentlocation$

$$evaluation = 1.2 \text{ x } evaluation$$

Rule 2 If $location(EE) =$ "ANY"

$$evaluation = 0.9 \text{ x } evaluation$$

Phase 2 Evaluates subject-object coincidences

Rule 3 If $object(EE) \cap subject(SSE) \neq 0$

$$evaluation = 1.0 \text{ x } soCriteriaWeight$$

Rule 4 If $object(EE) \cap subject(SSE) = 0$

$$evaluation = 0.7 \text{ x } soCriteriaWeight$$

Rule 5 If $object(EE) \cap object(SSE) \neq 0$

$$evaluation = 1.0 \text{ x } soCriteriaWeight$$

Rule 6 If $object(EE) \cap object(SSE) = 0$

$$evaluation = 0.7 \text{ x } soCriteriaWeight$$

Phase 3 Evaluates coincidence in type of SE and EE

Rule 7 If $type(EE) = type(SSE)$

$evaluation = 1.1 \text{ x } evaluation$

Rule 8 If $type(EE) \neq type(SSE)$

$evaluation = 0.8 \text{ x } evaluation$

Phase 4 Evaluates coincidence in concepts of EE

Rule 9 If $concepts(EE) \cap concepts(SSE) \neq 0$

$evaluation = 1.1 \text{ x } evaluation$

Rule 10 If $concepts(EE) \cap concepts(SSE) = 0$

$evaluation = 0.9 \text{ x } evaluation$

Phase 5 Evaluates coincidence in attributes of EE

Rule 11 If $attributes(EE) \cap attributes(SSE) \neq 0$

$evaluation = 1.0 \text{ x } evaluation$

Rule 12 If $attributes(EE) \cap attributes(SSE) = 0$

$evaluation = 0.8 \text{ x } evaluation$

Appendix E

Simulation Data

Iteration	GPS Reliability	DoI	DoA	System Feedback
0	0.5	0.67	0.57	False
1	0.5	0.67	0.67	True
2	0.5	0.86	0.76	True
3	0.6	0.76	0.76	True
4	0.7	0.76	0.95	True
5	0.8	0.95	0.86	True
6	0.6	0.67	0.95	True
7	0.6	0.76	0.76	True
8	0.8	0.67	0.67	True
9	0.7	0.76	0.19	True
10	0.8	0.57	0.1	False
11	0.7	0.48	0.19	False
12	0.6	0.57	0.1	False
13	0.5	0.67	0.19	False
14	0.6	0.48	0.19	False
15	0.5	0.19	0.19	False
16	0.1	0.29	0.48	True
17	0.2	0.19	0.67	True
18	0.1	0.1	0.76	True
19	0.3	0.19	0.67	True
20	0.2	0.1	0.57	True
21	0.1	0.19	0.29	False
22	0.1	0.1	0.19	False
23	0.2	0.29	0.19	False
24	0.3	0.19	0.1	False
25	0.3	0.29	0.19	False
26	0.2	0.38	0.29	False
27	0.6	0.29	0.19	True
28	0.4	0.48	0.29	True
29	0.6	0.38	0.38	True
30	0.7	0.38	0.29	True
31	0.8	0.38	0.48	True
32	0.6	0.57	0.57	True
33	0.7	0.38	0.76	True
34	0.6	0.57	0.67	True

Appendix F

Pilot Test Results

	User 1	
No	**Evaluation criteria**	**Comments**
1	Length or amount of information at each iteration	Good, just the right length
2	Ease of use of the user interface	Easy to use
3	Recall questionaires	Questions are too hard, multiple choices would be better
4	Guide's appearance	Bald, but no major comment, Looks OK
5	Speed of speech	Fine
6	Other comments	Incorrect reading of year (Eg. 1945 is sometimes read as one thousand nine hundred and forty five and sometimes nineteen forty five)
	User 2	
1	Length or amount of information at each iteration	A bit too much information, autoscroll would be nice because scrolling while listening complicates the process and affects concentration, the guide should either talk slower or make the story shorter
2	Ease of use of the user interface	Fine
3	Recall questionaires	Subjective questions is acceptable
4	Guide's appearance	Looks fine
5	Speed of speech	A bit too fast
6	Other comments	Give an introduction to Los Alamos site before the tour; sometimes, the arrow is not giving the right direction; update rate of directional arrow should be increased, multimedia presentation would be nice

No	Evaluation criteria	Comments
	User 3	
1	Length or amount of information at each iteration	Amount of information is acceptable but some iterations of the stories are a bit too long
2	Ease of use of the user interface	Fine, easy to use
3	Recall questionaires	Multiple choice questions would be better
4	Guide's appearance	A bit funny because he is bald
5	Speed of speech	A bit fast
6	Other comments	Attention and concentration level is highly affected by interaction condition eg. weather; increase update rate of directional arrow
	User 4	
1	Length or amount of information at each iteration	Amount of information is acceptable, length is acceptable as well
2	Ease of use of the user interface	Fine
3	Recall questionaires	Subjective questions with hints or multiple choice questions are better
4	Guide's appearance	Fine
5	Speed of speech	Speech is unclear and is a bit fast
6	Other comments	An option for repetition of the story would be nice; weather and coldness affect concentration, sound of the wind is louder than the speech provided; display the processing... icon for a longer interval and ask the user to move around before presenting the directional arrow; listening and scrolling at the same time is distracting
	User 5	
1	Length or amount of information at each iteration	Length of the story is a bit long, amount of information a bit long, stories are interesting, 3 to 4 iterations at each location is enough
2	Ease of use of the user interface	Easy to use, good
3	Recall questionaires	Subjective question is acceptable
4	Guide's appearance	The guide's appearance fits the story context well as it gives an impression of authority
5	Speed of speech	Speech system is good and clear
6	Other comments	Update rate for directional arrow should be increased; include instructions to turn left or right; more friendly greeting and a brief introduction to the whole tour (Eg. the number of available attractions, number of stories available) before the tour starts; speech recognition system would be a benefit; inclusion of music will increase enjoyment

Appendix G

Evaluation Questions

* All rating is based on 7-point Likert Scale

G.1 Preliminary Questions (Prior to the tour)

1. Please rate your experience of using mobile technologies
2. Have you ever been on a guided tour?
3. If you answer yes to question 2, what type of guided tour(s) was it?
4. How familiar are you with the story of the Manhattan Project, the project that developed the first nuclear weapon by the United States?
5. How interested are you with the topic of the Manhattan Project?
6. What is your opinion about the development of the 'atomic bomb'?

G.2 Questionnaire A (After the tour)

G.2.1 Storytelling

1. Please rate how intelligent the guide's discourse was
2. Please rate how believable the guide's discourse was

3. Please rate how emotional the guide's discourse was
4. Please rate how much the stories relate to your chosen interest(s)
5. How well do you think the guide was adjusting the stories based on your feedback?

G.2.2 The Guide

Facial Expressions

6. Please rate how intelligent the guide's appearance was
7. Please rate how believable the guide's facial expressions was (To what extent did the guide's facial expression correspond to its emotional state)
8. Please rate how natural the guide's facial expression was
9. Please rate how emotional the guide's facial expression was
   - What emotions did you detect? (List as many as you can or leave blank if there are none)
   - Did you notice a color bar beside the guide's face? Can you predict its function?
10. Please rate how appropriate the guide expression was (To what extent did the guide expression correspond to the feedback you gave?)

Guide's Character

11. Please rate how much you think you know about the guide's personality
    - What role do you think the guide might have played in the Manhattan Project?
    - Please write down 3 words to describe the guide's personality

12. Please rate to what extent is the guide analogous to a real tour guide
    - If you see some resemblance of the guide to its real counterpart, in what way?

G.2.3 The Tour Experience

13. Please rate how interesting the stories were
14. Please rate how meaningful do you find the tour is (How much better off you are after the tour in terms of knowledge about the Manhattan Project?)
15. Please rate how engaged do you feel during the tour session
16. Please rate the overall tour experience
17. Please rate how much information is provided to you

G.2.4 Interaction Interface

18. Please rate how easy to use the graphical user interface was
19. Please rate how comfortable the interaction process was
20. Please rate how compelling the navigation was

G.2.5 Comments and Suggestions

21. What is the best part of the system?
22. If you are allowed to change one thing in the system, what will it be?
23. Other comments

G.3 Questionnaire B (After the tour)

G.3.1 Multiple Choice Questions

1. After the reorganisation, which divisions were expanded to help with the workload of the Trinity Test?
   (a) The Experimental Physics Division and the Chemistry Metallurgy Division
   (b) The Explosive Division and the Chemistry Metallurgy Division
   (c) The Theoretical Physics Division and the Chemistry Metallurgy Division

2. Which was the first building completed in the Los Alamos Technical Area?
   (a) The Explosive Division
   (b) The Gadget Division
   (c) The Theoretical Physics Division

3. When was the Trinity test fired?
   (a) July 14, 1945
   (b) July 15, 1945
   (c) July 16, 1945

4. Who staked his claim on history with the success of Trinity Test?
   (a) General Leslie Groves
   (b) Robert Oppenheimer
   (c) Thomas Farrell

5. Where was the weekly colloquia among the scientist held?
   (a) The Main Hall of the Fuller Lodge
   (b) The blue door building beside the Fuller Lodge
   (c) The room to the right of the entrance of the Fuller Lodge

G.3.2 Subjective Questions

1. How did the coming of the atomic bomb change the world?

2. Do you agree with the guides opinion about the employment of the atomic bomb?

3. What do you agree most with the guides argument?

4. What do you disagree most with the guides argument?

5. Does your opinion about the atomic bomb change in any way before and after listening to the stories of the guide?

Appendix H

Complete Results

The disk contains two main folders: 'Experiment 1' and 'Experiment 2'. Each of the folders has the following hierarchical structure.

- Experiment X
  - Summary
    - Emotional Guide A
    - Non Emotional Guide B
    - Random Emotions Guide C
    - Combination
  - Original
    - Emotional Guide A
    - Non Emotional Guide B
    - Random Emotions Guide C

Under the 'Summary' directory, the three different 'Guide' folders contains **.doc* files that summarised the participants' subjective responses. On the other hand, the 'Combination' folder contains **.xls* files that summarised the participants rating for all the different aspects evaluated and the results of analysis are provided in **.spo* files. The 'Original' folder contains scanned copies of the original evaluation questionaires where all the summaries were extracted from. The content of the **.doc* and **.xls* files are listed in the following table:

Details	**File name**
Summary of the participants' interest area(s) and weather condition when they took the tour	*Subjects Info.doc*
Summary of the participants' opinion about the guide's facial expressions and personality	*The Guide.doc*
Summary of the participants' overall comments on the system	*Comments.doc*
Summary of the participants' subjective responses to the guide's arguments	*Subjective Opinions.doc*
Rating on all DVs for the three guides	*Experiment x.xls*
The participants' prior experience and recall scores	*Preliminary and Recall.xls*
Complete analysis of the results (SPSS software required)	*Experiment x.spo*
Rating on all DVs for the three story domains	*BtwInterest.xls*
Complete analysis of the story domains (SPSS software required)	*BtwInterest.spo*

Experiment 1 only: **Results for male participants only**	
Rating on all DVs for the three guides	*Male.xls*
Male participants' prior experience and recall scores	*Preliminary and Recall Male.xls*
Complete analysis of the results (SPSS software required)	*Male.spo*

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